BULLETIN OF MISCELLANEOUS INFORMATION No. 7 1926

ROYAL BOTANIC GARDENS, KEW

XXXIV.—THE FUSARIA OF JAMAICA.

C. G. HANSFORD,
Microbiologist, Dept. of Agriculture, Jamaica.

INTRODUCTORY.

In connection with experimental work on the Panama Disease of the Banana (*Musa sapientum*), the writer found it necessary to examine the *Fusarium* flora of a large number of soil samples. In the course of this work a large number of strains of *Fusarium* was isolated, and the present paper represents an attempt to classify these strains into species as far as is possible, and to correlate these with species previously described. Not only were many of these *Fusaria* isolated from soil samples, but many others were obtained from plant specimens and debris collected from time to time. While no claim is advanced that the complete *Fusarium* flora of Jamaica is represented in the present work, it is hoped that this will serve as a basis for future work, and a slight contribution towards our knowledge of the distribution of the various species of the genus.

With the exception of the *Fusarium* causing the Panama Disease of the Banana (*Fusarium cubense* Smith, emend. Brandes) the various species enumerated here have been studied only from a purely morphological standpoint. The writer hopes to be able to carry out extensive inoculation experiments with these species in the near future, to test the pathogenicity of each group of strains. Many strains of *Fusarium* have been isolated during the present work from diseased portions of plants other than the banana, but whether these strains were the actual causes of the symptoms observed cannot be stated definitely at the moment. In Jamaica it has been found that the dead and dying roots of many different plants contain various strains of *Fusarium* in the tissues, and that the plants themselves show the symptoms of a wilt disease. The greater number of the *Fusaria* found in such situations are undoubtedly saprophytic in habit, but it is more than probable that some are to some degree parasitic, causing wilt symptoms in the plants attacked. Not only is it important to decide whether or not these fungi are parasitic in habit, but also the conditions under which they are able to attack these plants must be determined in the case of those strains found to be parasitic. Also very little work has been done up to the present in determining the host range of the various members of the genus known to be parasitic.

(585) Wt. 55—7, 1,000. 7/26. Wy. & S., Ltd. Gp. 50 (4).

Many of the strains used in the course of the present work were isolated from soil samples collected from various parts of Jamaica. The isolation of *Fusaria* from these soil samples was accomplished by one of the two methods outlined below.

In many cases the specimens as received in the laboratory consisted of a single lump of moist clayey soil, and it was found necessary to carry out some preliminary manipulations before proceeding to the actual isolation of the *Fusaria*. The soil was broken up and exposed to the air to dry, after which it was reduced to a coarse powder. Then in this form it was used for the isolation of the fungi.

Method 1.—A little of the powdered soil was added to a tube of sterile water and shaken up. A little of this suspension was used to inoculate a series of Potato Agar dilution plates. These were incubated at the ordinary room temperature for about four days, when they were examined, and any colonies of *Fusarium* which appeared were transferred to tubes of the same medium. After about ten or fourteen days these tubes were examined and duplicates were discarded as far as possible, at this early stage. The remaining cultures were plated out in an ordinary dilution series, from which "Single Spore Strains" were isolated of any strains which appeared to differ in any respect. Usually it was found that the original tube culture made by transfer from the plates of soil was a pure culture of a single *Fusarium* as shown by the uniformity of the colonies obtained in the second dilution series from it. In a few instances, however, the original tube cultures were contaminated with bacteria, and in some cases were found to be a mixture of two *Fusaria*. Eventually each distinct strain isolated from a given sample of soil was obtained as a "single spore strain" in pure culture. These cultures were kept as stock cultures for use in the comparison of the strains with each other. This method of isolation proved extremely laborious and various modifications were tried with the object of saving as much time and labour as possible, with the result that another method was used in the latter part of the work, the former method described above being used occasionally as a check upon the second and shorter method.

Method 2.—A thick paste of starch, preferably "semolina" or "ground rice," was made up with cold water, and spread in a layer of $\frac{1}{16}$ to $\frac{1}{8}$ inch thick over the bottom of large Petri dishes about 8 to 12 inches in diameter, and about $\frac{3}{4}$ to 1 inch in depth inside. The covers were placed over the dishes, and the whole sterilised in the autoclave for 20 minutes at 15 lbs. pressure. On cooling the plates were taken out and placed in a sterile chamber. The soil specimens, prepared as described above, were sifted lightly over the surface of the paste in the dishes under as sterile conditions as was possible. Not only did this medium prove an excellent one for the development of the *Fusaria* at the expense of certain other common

saprophytes, but they developed the colours on the rice medium which are typical of the sections of the genus to which they belong. After about four days it was an easy matter to distinguish the colonies of the various fungi growing in the dishes from each other. From the *Fusarium* colonies a few spores were taken and inoculated into a dilution series of Petri dishes of Potato Agar, from which single spore strains were isolated in the usual way. In the case of those *Fusarium* colonies which did not form spores on the paste in the large dishes, a little of the colony was transferred to a tube of Potato Agar, on which medium spores were usually formed in quantity. From this culture, in turn, a single spore strain of each strain was isolated in the usual way.

This method proved much less troublesome than the first, as the original colonies of *Fusarium* were not contaminated with bacteria to the same extent as those developed by the planting of the soil specimens on the Potato Agar as in the first method. Most of the colonies on the starchy paste developed much aerial mycelium in those cases where large quantities of conidia were not formed, and this aerial mycelium was used as inoculum for a culture on Potato Agar, on which spores were formed quite readily. The paste proved a good medium for the cultivation of the *Fusaria* in the soil specimens at the expense of other soil fungi which were not wanted in the present work. The only exceptions to this general rule were species of *Mucor* and of *Oedocephalum* which overran the colonies of *Fusarium* in both the paste and the agar plates.

Most of these soil specimens were examined with the original intention of determining whether or not they contained *Fusarium cubense*, the organism causing the Panama Disease. By the second method of isolation it was much easier to recognise the colonies of the *Elegans* group, to which *F. cubense* belongs, as they give a delicate pink-tinted, well developed aerial mycelium under such conditions. Special attention was given to this section of the genus during the whole of the present work.

Many of the strains used during the course of the work were isolated from dead and dying banana material (" trash "). These strains were usually isolated direct from the colonies developing on the surface of the " trash " when this had been kept for a day or two in a moist chamber. All strains were finally isolated as " single spore strains."

In the case of the large number of strains isolated from the vascular bundles of banana plants affected with the Panama Disease, small pieces of the affected bundles were cut out from the tissues showing the first stages of the disease, and were planted in dishes of agar, or starch paste, under sterile conditions. The second method proved more rapid than that using agar, but in many cases both methods were used for the same specimen. All strains thus isolated were re-isolated as " single spore strains."

Those strains isolated from fruit and tuber rots were obtained by planting pieces of the rotting tissues in Potato Agar plates. The

portions used for these plantings were cut under sterile conditions from the advancing edges of the rot, and almost always gave pure cultures of the *Fusarium* contained in the rot.

Classification of the Genus Fusarium.

Link, Mag. Ges. nat. Freunde, 3 : 10. 1824. Saccardo, Sylloge Fungorum, 4 : 694. 1886. Appel & Wollenweber, Arb. K. biol. Anst. Land.- u. Forstw. 8 : 60–61. 1910. Wollenweber, Phytopathology, 3 : 24–50, 197–240. 1913. Wollenweber, Ber. deut. Bot. Gesell. 31 : 17. 1913. Wollenweber, Journ. Agric. Res. 2 : 251–285. 1914. Sherbakoff, Cornell Univ. Exp. Sta. Mem. 6 : 1915.

The modern conception and diagnosis of the genus is due to the work of Appel and Wollenweber, continued by Wollenweber in his more recent papers. Their description of the genus, as translated by Morris and Nutting (5), is as follows :

" *Synonomy : Atractium*, Link, p.p. in Mag. Ges. Nat. Freunde, 3 : 10. 1809. *Fusidium*, Link, p.p. in Mag. Ges. Nat. Freunde, 7 : 10. 1816. *Fusidium*, Link, p.p. in Spec. Plant. 11 : 96. 1825. *Fusisporium* Link in Spec. Plant. 1 : 30. 1824. *Selenosporium* Corda Icon. 1 : 7. 1837. *Fusoma* Corda Icon. 1 : 7. 1837. *Pionnotes* Fries Sum. Veg. Scand. 481 : 1849 ; Sacc. Syll. 4 : 725.

" Conidia more or less polar, mostly dorsiventral, seldom distinctly round (radiar), more or less curved ; when ripe usually septate ; more or less coloured when in masses ; borne one after another in the same spot, but not connected in chains, on the ends of simple or branched septate conidiophores, which appear spread out between the hyphae or joined as they are in coremia, or grouped together in sporodochia. Conidia spread out in a powdery form between the hyphae or tubercular-like on a limited gelatinous sporodochium, a slimy layer, or occasionally as pionnotes without definite boundaries. Chlamydospores oval or pear-shaped, single or in bunches, in chains or bunched up, remaining joined for some time, terminal or intercalary, not more than one borne in the same place. The chlamydospore is not very different from the conidiophore and it has no distinctive colour. It never gathers in gelatinous layers.

" Hyphae septate, variously branched, epi- and endo-phytic, occurring sparingly or in great quantity, either isolated or together, curly or thick, partly like coremia or especially like a stroma to plectenchymatic form with definite shape or without definite shape, more often similar to an even growth all over, limited or spread out, often closed up together on the inside, occasionally building up bright mycelium. Note that it is undecided whether species that do not have septate conidia should be kept separate from the genus, or be placed in a subgenus *Fusamen*, according to Saccardo (6) ; but there is no question about those which have a tendency towards septation as *F. orthoceras*. It is also undecided in what order of importance the characters should be taken. The choice is between septations, dorsiventrality, polarity, and the curve of the long axis of the conidia. It is very questionable whether *Fusarium* should be placed under *Leptosporium* as in Saccardo, and nothing but the study of the

different forms can decide the boundaries of the genus. Concerning the colour of the conidial masses it can be said that black does not appear normally, neither does black mycelium. Light orange and ochre colours predominate in the conidia. The mycelium has also yellow, red and blue. The term sclerotium as used in *Fusarium* is disputable. Researches have not shown that the term sclerotia was justifiable for the structures found."

Since this, Wollenweber (9) has excluded from the genus *Fusarium* all fungi having straight conidia, transferring them to the genera *Ramularia* and *Cylindrocarpon*.

Sherbakoff (7) describes the genus as follows :—

" Hyphomycetes with from hyaline to bright, but never plain grey nor black, conidia and mycelia : conidia sickle-shaped septate (usually 3 or more septate) apically pointed, mostly pedicellate, not appendiculate, not catenulate ; conidia scattered over the substratum, in pseudopionnotes or in sporodochia, the latter with or without from flat to wartlike plectenchymatic substratum, and always without any differentiated or enclosing structures ; conidiophores from simple to irregularly verticillate."

The modern attempts to classify and group the great number of species of *Fusarium* now known, are based on the work of Appel and Wollenweber (1). This work was continued by Wollenweber (8), who has collected the various species into groups of species having related characters. These sections are based chiefly on the shape of the conidia, and those originally described by Wollenweber are still used to-day. The sections *Martiella*, *Discolor*, *Gibbosum*, *Roseum* and *Ventricosum* described by him contain a large number of wound parasites, capable of causing a destruction of parenchymatous tissues. The section *Elegans* contains a number of vascular parasites which cause the wilt diseases of a number of important crops. Wollenweber's later papers have dealt with the grouping of a large number of species in these sections, and other sections have been added to those he originally described. Sherbakoff (7), working in America, described the " Fusaria of Potatoes " occurring there in great detail, and grouped them in Wollenweber's sections as far as was possible, adding other sections where he found it necessary. Owing to the very slight differences between many of his species and varieties, his classification has become much complicated, and had he allowed his conception of the species to broaden a little he would have found many of these to be unnecessary.

As noted by Morris and Nutting (5) the great obstacle in the way of identification work on the species of *Fusarium* is the lack of a good monograph of the genus, and the different conceptions of the boundaries and range of a single species in the genus, as used by the various workers on it. The most comprehensive of the various keys to the species of *Fusarium* is that given by Wollenweber (11) and the present work is largely based on that key. He does not, however,

include in this key many of the species which he mentions in a former paper (12), which is much to be regretted.

Wollenweber has recognised that many of Sherbakoff's species are unnecessary, as he has regarded them as synonyms of species previously described.

The Sections and Species Found in Jamaica.

The arrangement of the sections and species followed in this paper is that of Wollenweber and his co-workers, as published in their more recent papers (12, 13 and 14).

Wherever possible I have utilised the descriptions of the various species and varieties published by these authors, so as to avoid unnecessary complication. In each case the author and reference are given.

I.—Section **Eupionnotes** Wr.

Wollenweber, Phytopathology 3: 38. 1914. Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915. Wollenweber, Ann. Myc. 15; 53. 1917; Ber. d. Deut. Bot. Ges. 35: 732. 1918. Reinking & Wollenweber, "Fusaria in Relation to Banana Cultivations."* United Fruit Co., Boston, 1925.

Reinking and Wollenweber give the following diagnosis of this section:

"Eupionnotes always present, spread out, dense, typical aerial mycelium absent, orange to salmon; conidia nearly cylindrical to sickle-shaped, moderately curved, slightly dorsiventral, apex ellipsoidal to conical, basis mostly apedicellate, septate, but septa frequently inconspicuous; chlamydospores one-celled, two-celled, in chains, rarely in heaps, or absent. Color type, orange to bright salmon."

1. **Fusarium affine** *Faut. & Lamb.*

Fautrey & Lambotte, Rev. Myc. Fr. 18: 68. 1896. Saccardo, Sylloge Fungorum 14: 1125. 1899. Sherbakoff, Cornell Exp. Sta. Mem. 6: 126. 1915.

Sherbakoff's description of the fungus is as follows:—

"Conidia straight, somewhat dorsiventral near apex, apedicellate, typically 1-septate, $10{\cdot}2 \times 2{\cdot}8$ $(9-11{\cdot}4 \times 2{\cdot}6-3)\mu$, usually in a continuous smooth or slightly roughened slimy layer, from hyaline to pale salmon-coloured on glucose agar; conidiophores from simple to sparingly branched, septate; mycelium hyaline; no chlamydospores.

"Hab. In tubers and stems of *Solanum tuberosum*, in greenhouse soil, New York.

"This organism was isolated repeatedly from various sources such as discoloured fibrovascular bundles of potato tubers from the base of wilted potato stems and from soil. Its size is exactly the same as that given by Wollenweber (9) for the conidial stage of *Mycosphaerella solani* (E. & E.) Wr. Wollenweber's illustrations (Plate xxi, Fig. N) are also much the same, and he considers *F. affine* Faut. & Lamb. as the conidial stage. The strain studied did not show any perfect form in culture, although it was grown for more than a year and on various media. This organism can be at once distinguished from all the other Fusaria by its minute, 1-septate, nearly straight conidia, and its inconspicuous slow growth."

---

* References to this work are from a mimeographed copy kindly supplied to me.—C. G. H.

The several strains of this fungus which were studied in the course of the present work agreed very closely with the above description. None of the strains formed any perfect stage in culture. For the identification of this species I am indebted to Dr. Sherbakoff.

In Jamaica the fungus has been found in a rot of the tubers and roots of *Zingiber officinale*, but the writer has not yet been able to test its pathogenicity to the ginger plant.

Wollenweber (12) considers that this species should be referred to the genus *Hymenula* on account of its almost straight conidia.

2. **Fusarium dimerum** *Penzig.*

Penzig, Michelia 2 : 484. 1882. Saccardo, Syll. Fung. 4 : 704. 1886. Lindau, Rab. Krypt. Fl. Pilze, 9 : 566. 1910. Appel & Wollenweber, Arb. K. biol. Anst. Land.-u. Forstw. 8 : 37. 1910. Sherbakoff, Cornell Agr. Expt. Sta. Mem. 6. 1915. Wollenweber, Ann. Myc. 15 : 9. 1917 ; Ber. d. Deut. Bot. Ges. 35 : 732. 1917.

Reinking and Wollenweber (13, p. 11) give the following diagnosis of this species :

" Pionnotes pale cinnamon-pink to orange-pink, moderately spread out ; tubercular sporodochia present ; conidia curved, approaching pedicellate, typically 1-septate, 13·5 × 2·75 (8—18 × 2·0—3·5) μ, often 0-septate, 12 × 2·75 (4·5—16 × 2·0—3·5)μ ; stroma erumpent, chlamydospores 3·5–6 μ diam. in mycelium and conidia.

" Habitat : On cut surface of decaying banana pseudostem and in the soil, Tela, Honduras, Central America."

A culture of this organism was isolated by the present author from some decaying wood debris at Hope, and was found to agree with the above description. The measurements of the conidia on different media agree with those given by Reinking and Wollenweber (loc. cit.) rather than with those of Sherbakoff (loc. cit. p. 128) who gives the average width of conidia considerably larger than those found in my cultures.

V.—Section **Arthrosporiella** Sherb.

Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915. Wollenweber, Ber.-d. Deut. Bot. Ges. 35 : 733. 1917. Wollenweber & Reinking, Phytopathology 15 : 157. 1925.

Wollenweber and Reinking (loc. cit.) give the following diagnosis :

" Aerial mycelium abundant, whitish to flesh colour, sporodochia and pionnotes present ; microconidia in aerial mycelium, spindle-shaped or lanceolate, apedicellate, 0–3-septate ; macroconidia in masses, isabella color or ochraceous, sickle-shaped, attenuate, often pedicellate, 3-more septate ; chlamydospores typically intercalary, stroma ochraceous to chestnut-brown or rosy, spread out, sometimes sclerotially erumpent."

3. **Fusarium semitectum** *Berk. & Rav.*

Berkeley, Grevillea 3 : 98. 1875. Saccardo, Syll. Fung. 4 : 718. 1886. Wollenweber, Ann. Myc. 15 : 11. 1917. Wollenweber & Reinking, Phytopathology 15 : 157. 1925.

" Aerial mycelium white to flesh colour or isabella colour, stroma plectenchymic, dark ochraceous sometimes violet-carmine ; chlamydospores intercalary ; sporodochia absent, conidia scattered in aerial mycelium, spindle-shaped,

lanceolate, slightly curved, apedicellate, appendicular, when smaller 0–2-septate, when larger 3–5- (6–7) septate; 0-septate 12×3·0—3·5 μ; 1-septate 11—21×2·5—4·5 μ; 2-septate 16—24×3·25—5·0 μ; 3-septate 18 — 40×3·0 — 5·5 μ; 4-septate 29 — 45×4·0 — 5·5 μ; 5-septate 36—52×4·0—5·5 μ; 6–7-septate 37—57×4·5—5·5 μ.

"Hab. At blossom end rot of tomato, in dead floral parts, decaying fruit and interior of pseudostem of diseased banana plant (*Musa sapientum*), and in the air. Honduras, Central America."

In Jamaica this species has been found on the remains of the flowers at the end of banana fruits, and also once from decaying banana fruit (*Musa cavendishii*), in this case apparently having spread from the decaying floral parts back into the fruit itself.

In culture the organism appeared to satisfy the above diagnosis, except that it did not develop any violet carmine colour in culture. Reinking and Wollenweber (13, p. 17) mention that some strains of this organism do not develop this colour.

4. **Fusarium anguioides** *Sherb.*

Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915.

Sherbakoff describes the species as follows:

"Conidia of diverse type ranging from arthrosporial (short spindle-shaped with more or less rounded ends, 0- and 3-septate) to typically slightly curved or nearly straight and anguiform, 1- to 15-septate, 1- and 3-septate conidia typical for the first form and measuring 27×4·4 (20—38×3·9—5·3) μ; for the other form the conidia commonly measuring as follows:

5-septate, 51×4·2 (47—68 ×3·9—4·6) μ.
6–7-septate, 76×4·6 (65—86 ×4·2—5·2) μ.
8–9-septate, 89×4·86 (80—102×4·3—5·8) μ.

Colour of conidia in pseudopionnotal layer, on glucose potato agar, ranging from light pinkish cinnamon to cinnamon; arthrosporial conidia of common occurrence on aerial mycelium but often the latter, especially on different agars, nearly absent, when a thin spore layer, pseudopionnotes, is produced for which anguiform conidia are typical."

In Jamaica the present writer has isolated cultures of this species from decaying plant debris and from soil in several districts, and it appears to be a common saprophyte in these situations. I am indebted to Drs. Reinking and Wollenweber for the identification of my cultures of this organism. They remark as follows (13):

"The writers observed in addition, intercalary chlamydospores in mycelium and conidia; no sporodochia were observed, but pionnotes developed. . . . The main part of the spores are developed from the mycelium. *F. anguioides* represents a border line strain to section Roseum, and resembles in some characters *F. anthophilum* (A. Br.) Wr., from which it differs in higher septation of conidia, and by the presence of chlamydospores."

VI.—Section **Gibbosum** Wr.

Wollenweber, Phytopathology 3: 31. 1913. Sherbakoff, Cornell Exp. Sta. Mem. 6. 1915. Wollenweber, Ber. d. Deut. Bot. Ges. 35: 734. 1917.

Reinking and Wollenweber (13, p. 32) give the following diagnosis of this section:

" Mycelium from white to brown; conidial mass typically pale buff to cinnamon and sepia; conidia in sporodochia and pionnotes, pale ochraceous to orange, dorsiventral sickle-shaped, elliptical with parabolical or hyperbolical curves, attenuate at both ends, pedicellate; sometimes smaller conidia in aerial mycelium, comma-shaped, 0–3-septate, rounded at both ends or slightly constricted, apedicellate; chlamydospores intercalary in mycelium and conidia, sclerotia rare, sometimes dark blue; stroma plectenchymic, ochraceous, chestnut brown or carmine."

5. **Fusarium bullatum** *Sherb.* var. **minus** *Wr. & Reinking.*

Wollenweber & Reinking, Phytopathology 15: 159. 1925.

" Differs from the type species by smaller conidia; conidia in sporodochia or in pionnotes, pedicellate, mostly 3-septate 21—40×3·0—4·0 μ; seldom 4–5-septate; 5-septate 33—42×3·5—4·5 μ; conidia in aerial mycelium sometimes subnormal apedicellate, 3 (1–5)-septate." (Wollenweber & Reinking, loc. cit.)

This fungus was isolated from rotting plant debris at Hope Gardens, and also from plant debris near the Hope River at Papine.

6. **Fusarium bullatum** *Sherb.*

Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915. Wollenweber & Reinking, Phytopathology 15: 159. 1925.

Sherbakoff's diagnosis is as follows:

" Conidia . . . usually distinctly pedicellate, mostly 5 - septate 42×4·3 (31—47×4·1—4·9) μ, from pale cream to salmon in colour; chlamydospores intercalary in mycelium mostly in chains and from small to large clusters; aerial mycelium nearly always well developed, of uniform height and density, nearly pure white in colour; substratum on various agars from colourless to a tint of light buff."

This species has been isolated in Jamaica by the present author from soil in banana cultivations in Portland and St. Mary, and from plant debris (chiefly parts of old leaves of banana) in these same cultivations.

7. **Fusarium ossicolum** (*Berk. & Curt.*) *Sacc.*

Saccardo, Syll. Fung. 4: 714. 1886. Wollenweber, Ann. Myc. 15: 15. 1917.

This fungus was isolated from dead and decaying banana leaves in Portland and St. Mary, and also at Virgin Valley, St. James, and was identified for me by Drs. Reinking and Wollenweber, whose diagnosis is here given:

" Light orange mycelium and conidial mass; conidia in sporodochia and pionnotes, curved spindle-shaped, sickle-shaped, middle cells broad in comparison to the longer end cells, end cell often slender, pointed and often curved; 5 (3–5)-septate, 27—48×3·75—4·5 μ; 0-septate 9—11×3·0—4·5 μ; 3-septate, 23–26×3·75 μ; 4-septate, 23—26×4·5—5·25 μ; chlamydospores intercalary or sometimes terminal." (13, p. 37.)

8. **Fusarium falcatum** *App. & Wr.*

Appel & Wollenweber, Arb. K. Biol. Anst. Land.-u. Forstw. 8: 175. 1910. Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915. Wollenweber, Ann. Myc. 15: 15. 1917.

" Mycelium white to ochre. Conidial masses ochre, yellowish brown or reddish ochre. Conidia, sporodochia and pionnotes present; curved spindle-

shaped, sickle-shaped, middle cells very broad in comparison to the much longer end cells, with long and narrow apex, prominently pedicellate, parabolic to hyberbolic curves, typically 5 (3–5)-septate, 46×4·75 (36—65×3·5—6·0) μ; 3-septate, 27×4·0 (23—32×3·5—4·5) μ; 4-septate 37×4·0 (29—42×3·5—4·5) μ; rarer 6–12-septate; 10-septate 83×5·5 μ; chlamydospores 6–14 μ diam., intercalary or sometimes terminal in mycelium and conidia; 1-celled, 2-celled, in chains or masses." (Reinking & Wollenweber, 13, p. 36).

This species has been found in Jamaica in soil and on dead wood and plant debris at Hope Gardens.

9. **Fusarium acuminatum** *Ell. & Ev., emend. Wr.*

Ellis & Everhart, Proc. Acad. Sci. Phila. 441. 1895. Saccardo, Syll. Fung. 14: 1125. 1899. Wollenweber, Journ. Agr. Res. 2: 269. 1914.

Wollenweber gives the following diagnosis:

"Conidia scattered, in sporodochia or in pionnotes, orange in mass; conidia average as follows: 5-septate, 40—70×3·0—4·0 μ; 4-septate (less common) 30—60×3·0—4·5 μ; 3-septate, 20—45×2·75—4·25 μ; 0-, 1-, 2-, 6- and 7-septations occasionally found; subnormal small conidia may easily be mistaken for conidia of the section *Discolor* but normal sporodochia develop on repeatedly whorl-like branched conidiophores, giving the characteristic conidia of the section Roseum; conidia in side view with hyperbolic or parabolic curves, in contrast to *Fusarium herbarum* (Cda.) Fr., the conidia of which are less curved; chlamydospores present, intercalary in mycelium and conidia, sometimes single, but mostly in chains and clusters; blue globose sclerotia, 50—70 μ thick form a striking contrast to the carmine plectenchymatic thallus on starchy media, such as steamed potato tubers. Both blue and carmine are basic modifications of the fungus, while yellow (on rice) is the acid one, turning blue to purple violet with the addition of an alkali."

A culture closely corresponding with the above description was isolated in Jamaica from the rotting tissues of a banana rhizome which had succumbed to the wilt disease. When first isolated the culture agreed very closely with the diagnosis above, except that blue sclerotia were not produced in culture. Soon after the culture was isolated it appeared to undergo some kind of degeneration, and for a period of 18 months no typical sporodochia or pionnotes were formed in any culture made from it. Finally in an old culture on potato tuber plug typical sporodochia were again formed, and subcultures from these have proved identical with the characters of the original isolation. No sclerotia have at any time been produced in cultures of this strain, which is the only representative of this species so far isolated in Jamaica.

Measurements of the conidia are as follows:

On Potato tuber plug, 28 days old, conidia from a large sporodochium:

3-septate 15% 26—48×2·7—4·5 (36×3·7) μ.
4-septate 15% 28—52×3·0—4·5 (41×4) μ.
5-septate 60% 38—76×3·4—4·8 (54×4·3) μ.
6-septate 10% 54—78×4—4·8 (63×4·5) μ.

On Tomato stem plug, 35 days old, conidia from sporodochium:

3-septate 10% 30—54×3—4·7 (42×3·8) μ.
4-septate 15% 33—60×3—4·8 (48×4) μ.
5-septate 65% 41—75×3·3—5 (58×4·3) μ.
6-septate 10% 56—80×4—4·8 (66×4·5) μ.

10. **Fusarium caudatum** *Wr.*

Wollenweber, Journ. Agric. Res. 2 : 262. 1914.

" Conidia with a tail or whip-like prolongated apical cell and a pedicellate base with well marked heel, ochreous to salmon coloured in mass, formed in sporodochia and pionnotes ; 5-septate conidia averaging 40—80 × 3·0—4·5 μ, lower and higher septations more rarely occur ; chlamydospores brown, 7—14 μ diam., as a rule intercalated in chains or clusters, but frequently single if formed from the content of the cells of conidia under poor conditions, such as in water." (Reinking & Wollenweber, 13, p. 43.)

This organism was isolated twice, from soil, and from the vascular bundles of a banana (*Musa sapientum*) attacked by wilt disease, where it was a secondary invader, following on the *Fusarium cubense* causing the disease. The culture was identified for me by Drs. Reinking and Wollenweber.

VII.—Section **Roseum** Wr.

Wollenweber, Phytopathology 3 : 32. 1913. Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915. Wollenweber, Ber. d. Deut. Bot. Ges. 35 : 739. 1917.

" Conidia broad ellipsoid, typically of an even diameter for a considerable part of their length, comparatively narrow, very gradually attenuate toward both ends, approaching sickle-shaped, top cell long, sometimes narrow filiform, base more or less pedicellate ; chlamydospores absent ; some species have blue coloured sclerotia. Color type : acid modification of aerial mycelium yellow, except in *F. anthophilum* and other related fungi." (13, p. 46).

11. **Fusarium herbarum** (*Cda.*) *Fr.*

Wollenweber, Ber. d. Deut. Bot. Ges. 35 : 739. 1917.

" Sporodochia minute, confluent, yellow, stromata sometimes carmine spotted ; conidia for the most part 5-septate, 48—56 × 4—4·5 μ, (when dry 3—4 μ broad), 3-septate 35–45 × 3·5—4·25 μ, blue globose sclerotia very rare, 40—80 μ diam." (11, p. 739.)

The present writer isolated an organism of this type only once during the course of the present work, from some dead twigs of *Coffea arabica*. The following is a description of these cultures :

Conidia from almost straight to elliptically curved, of even diameter through most of their length, with acute, attenuated apex, base pedicellate, produced in yellowish to pink sporodochia and in pseudopionnotes ; aerial mycelium white to pink, in some cultures almost entirely wanting ; no chlamydospores ; blue sclerotia produced only very rarely and very small ; substratum from almost hyaline to pink and brown shades, sometimes carmine.

Measurements of the conidia on different media are as follows :

On tomato stem plug :

3-septate 30% 30—40 × 3·5—4 (37 × 3·6) μ.
4-septate 30% 40—48 × 3·5—4·2 (43 × 4) μ.
5-septate 40% 40—50 × 3·5—4·5 (46 × 4) μ.

On potato Agar, culture 21 days old :

3-septate 60% 25—40 × 3—3·5 (32 × 3·5) μ.
4-septate 20% 37—45 × 3—4 (40 × 3·5) μ.
5-septate 20% 40—50 × 3—4 (46 × 3·5) μ.

On wood plug, conidia from large pink sporodochium :

3-septate 60% (30×3·2) μ.
4-septate 30% (38×3·2) μ.
5-septate 10% 36—48×3—4 (43×3·5) μ.

On potato tuber plug, 35 days old culture :

3-septate 50% 25—50×3—4 (42×3·8) μ.
4-septate 25% (43×4·2) μ.
5-septate 20% 40—60×4—4·5 (48×4·2) μ.
6–7-septate 5% 50—60×4—5 (53×4·5) μ.

12. **Fusarium herbarum** (*Cda.*) *Fr.* var. **gibberelloides** *Wr.*

Wollenweber, Ber. d. Deut. Bot. Ges. 35 : 740. 1917.

The following is a translation of Wollenweber's diagnosis :

" Differs from the type by the numerous large globose to warty sclerotia, which are blue-black like those of Gibberella." (loc. cit.)

A culture corresponding to the above diagnosis has been isolated in Jamaica on some dying *Citrus* twigs by the writer, whose cultures are thus described :

Conidia 5-septate, some 3-4 and 6-septate, of even diameter through most of their length, elliptically curved to almost straight, pedicellate, with acute ends, of uniform curvature, with acute attenuated apex ; no chlamydospores ; large blue-black nodulose sclerotia ; mycelium usually poorly developed, white to pink in colour as a rule, occasionally yellowish ; conidia produced in large yellowish sporodochia and in pseudopionnotes, plectenchymata red to brown in colour.

Measurements of the conidia are as follows :

On wood plugs, conidia from a large sporodochium in a culture 21 days old :

5-septate 95%
6-septate 5% } 50—60×4—5 (54×4·5) μ.

On tomato stem plug, conidia from pseudopionnotes, culture 21 days old :

3-septate 30% 35—52×3·5—4 (42×3·8) μ.
4-septate 30% 37—60×3·5—4·5 (45×4·2) μ.
5-septate 40% 40—60×4—4·5 (52×4·3) μ.

13. **Fusarium avenaceum** (*Fr.*) *Sacc.*

Wollenweber, Ann. Myc. 15 ; 14. 1917, gives the following synonomy : *F. Gaudefroyanum* Sacc. ; *F. subulatum* App. & Wr. ; *F. lucidum* Sherb.

The following description is taken from the present writer's cultures, and agrees fairly well with the descriptions of *F. subulatum* and *F. lucidum* given by Sherbakoff (7) :

Conidia entirely macroconidia, elliptically curved to almost straight, of uniform diameter through the greater part of their length, gradually attenuated toward both ends, apex prolonged, curved, acute, base distinctly pedicellate, typically 3-septate, averaging 28 × 4μ, 4-septate averaging 32 × 4μ, 5-septate averaging 36 × 4·2μ, and 6-7-septate averaging 45 × 4·5μ, produced in numerous small to large and convex sporodochia, also occasionally

converging into pseudopionnotes, from pale pink in colour to dirty cream or buff shades, no chlamydospores; no sclerotia; aerial mycelium well developed, from almost white to pale pink and cinnamon in colour; substratum from pale pink to brown in colour.

Measurements of the conidia on various media are as follows :—
On wood plug, culture 21 days old :

Conidia : 3-septate 20% 23—32×3·5—4·5 (27×4) μ.
4-septate 30% 25—35×3·5—4·5 (30×4) μ.
5-septate 40% 30—40×3·5—5 (36×4) μ.
6–7-septate rare 40—44×4·5 (42×4·5) μ.

On potato agar, culture 28 days old, conidia from pseudopionnotes :

3-septate 30% 26—36×3·5—4·2 (31×3·8) μ.
4-septate 10% 26—40×3·5—4·2 (33×3·8) μ.
5-septate 50% 30—45×3·5—4·5 (38×4) μ.
6-septate rare 40—55×3·5—5 (48×4·2) μ.

On tomato stem plug, culture 21 days old, conidia from a large sporodochium :

3-septate 10% (29×3·7) μ.
4-septate 5% (33×4) μ.
5-septate 80% 30—50×3·6—4·7 (44×4·2) μ.
6–7-septate rare 45—70×4—5 (52×4·5) μ.

On oat agar, culture 28 days old :

3-septate 30% (28×3·7) μ.
4-septate 10% (33×4) μ.
5-septate 50% 35—52×3·5—4·7 (39×4·2) μ.
6–7-septate 10% 40—56×3·9—5 (48×4·5) μ.

This fungus has been isolated by the writer in Jamaica from the discoloured vascular bundles of a rhizome of a plant of *Musa sapientum* showing an advanced stage of the wilt disease, and was accompanied by other Fusaria of the *Martiella* group; it has also been isolated from the roots of a dead specimen of *Saccharum officinarum*.

14. **Fusarium anthophilum** (*A. Br.*) *Wr.*

Braun, Rab. Fungi. Europ. no. 1964. 1875; Wollenweber, Ann. Myc. 15 : 14. 1917; Wollenweber & Reinking, Phytopath. 15 : 160. 1925.

"Stroma pale, never carmine, conidia scattered, in pionnotes, seldom in sporodochia, slender, attenuate at both ends, sickle-shaped, similar to *Fusarium herbarum*, pedicellate, 3–5-septate 35—70×2·5—4·0 (30—82×2·5—4·5) μ; rarely 6-more septate, scattered conidia lanceolate, slightly curved, attenuate at both ends, apedicellate or appendicular; chlamydospores absent." (14, 161).

Reinking & Wollenweber (13, p. 47) mention that this fungus is common on decaying and dead parts of various hosts in Central America, and that it can also be quite generally isolated from soil and air there. In Jamaica it would appear that it is not quite as generally distributed as in Central America, as up to the present I have found it in only one locality in Portland, growing on banana trash (debris of leaves, etc.) and on a rotting pod of *Theobroma cacao*.

The measurements of the conidia agree closely with those given by Reinking & Wollenweber (13, pp. 48-50).

VIII.—Section **Liseola** Wr., Sherb., Rkg., Joh., et Bail.

Wollenweber, Sherbakoff, Reinking, Johann & Bailey, Fundamentals for taxonomic studies of Fusarium. Journ. Agr. Research 30 : 833. 1925.

"Microconidia more or less formed in chains, spindle to ovoid in shape; macroconidia slender with a slightly constricted top end, and a pedicellate base, form and colour similar to section Lateritium, scattered, in sporodochia or in pionnotes, brownish-white to orange-cinnamon; chlamydospores absent, stroma white to violet, spread out or erumpent, often with sclerotia. Conidial stage of *Gibberella* section *Lisea* (Sacc.) Wr." (13, p. 50).

15. **Fusarium moniliforme** *Sheld.*

Sheldon, Nebr. Agr. Exp. Sta. Ann. Rept. 1903, 23–32. 1904. Saccardo, Syll. Fung. 22:1485. Wollenweber, Ann. Myc. 15 : 23. 1917. Wollenweber & Reinking, Phytopathology 15 : 162. 1925.

"Microconidia in chains or in false heads, formed in white to Isabella colour aerial mycelium, spindle to ovoid in shape, $5-12\times2\cdot25-4\cdot0\ \mu$; macroconidia delicate and slender, sickle-shaped, attenuate, pedicellate; scattered or in sporodochia or pionnotes, brownish-white to orange-cinnamon; mostly 3-septate, $30-36\times3\cdot0-3\cdot5$ $(23-48\times2\cdot25-4\cdot0)\ \mu$; fewer 1–4–5-septate; 1-septate $12-18\times2\cdot25-3\cdot5\ \mu$; 4-septate $37-53\times3\cdot0-3\cdot5\ \mu$; 5-septate $43-66\times3\cdot0-3\cdot5\ \mu$; chlamydospores absent; sclerotia blue, 0·5 mm. diam.; stroma violet or ochraceous." (14, p. 162).

This fungus has been found in Jamaica on diseased corn seeds (*Zea mays*), on diseased cobs of *Zea mays*, and from the rotting bud leaves of pineapple (*Ananas sativus*) at Hope, in conjunction with *Phytophthora* sp. The organism was also isolated from soil in various districts of Jamaica, and appears to be a common saprophyte.

IX.—Section **Lateritium** Wr.

Wollenweber, Ann. Myc. 15 : 54. 1917. Reinking & Wollenweber, Fusaria in relation to Banana Cultivations. United Fruit Co., Boston, 1925, p. 63.

"Mycelium white, rosy, yellow, sometimes carmine, aerial or immersed; chlamydospores frequently intercalary, but terminal always lacking; sclerotia knotty, rugulose, sometimes dark blue; stroma spread out, erumpent; conidia, spindle to sickle-shaped, dorsiventral difference in curvature more conspicuous towards the apex, constricted at both ends or even pedicellate at the base, resembling section Elegans, in tuberculate sporodochia, often protruded in long columns, in pionnotes or scattered in aerial mycelium. Imperfect stage of a *Gibberella*. Colour type similar to section Elegans, and sometimes to Discolor." (13, p. 54.)

16.—**Fusarium fructigenum** *Fr.* var. **maius** *Wr.* Forma 1, *Wr. & Rkg.*

Wollenweber & Reinking, Phytopathology 15 : 165. 1925.

"Conidia in sporodochia and pionnotes, orange, spindle to sickle-shaped, dorsiventral difference in curvature more conspicuous towards the top cell than in the middle, constricted at both ends or even pedicellate at the base, 5(3–6)-septate; 5-septate $48-64\times3\cdot5-4\cdot5\ \mu$; 6-septate $63-80\times3\cdot5-4\cdot75\mu$; 3-septate $34-44\times3\cdot5-4\cdot5\ \mu$; chlamydospores seldom present; sclerotia ($\frac{1}{2}$mm. diam.) dark blue or ochraceous white; stroma carmine. Differs from the type by carmine colour of the stroma." (14, p. 165).

This fungus was isolated only once in Jamaica by the present writer from an undetermined dead plant at Hope. It was identified for him by Drs. Reinking & Wollenweber.

Wollenweber, Phytopathology 3 : 31. 1913. Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6, 1915. Wollenweber Ann. Myc. 15 : 54. 1917 ; Ber. d. Deut. Bot. Ges. 35 : 736. 1917. Wollenweber et al, Journ. Agr. Res. 30 : 842. 1925.

Sherbakoff defines this section as follows :

" Conidia sickle-shaped, at the middle nearly cylindrical, or broader towards the apex, somewhat abruptly apically attenuated, distinctly pedicellate ; mostly 3- to 5-septate, 5-septate dominant ; microconidia typically absent ; chlamydospores intercalary only, usually scant ; mycelium typically well-developed with from nearly white to orange colour as type. Substratum from nearly colourless to chamois, pomegranate purple and spectrum red. Colour of conidia very variable, mostly cinnamon to orange."

17.—**Fusarium sulphureum** *Schlecht.*

Schlechtendal, 'F. berol. 2 : 134. 1824. Appel & Wollenweber, Arb. K. Biol. Anst. Land-u. Forstw. 8 : 115. 1910. Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6 : 1915. Wollenweber, Ann. Myc. 15 : 21. 1917 ; Ber. d. Deut. Bot. Ges. 35 : 737. 1917. Morris & Nutting, Journ. Agr. Res. 24 : 360. 1923.

A description of the present writer's cultures is as follows :—

Conidia entirely macroconidia, elliptically curved, or more or less uniform diameter through most of their length, apex short, abruptly attenuated, base distinctly pedicellate, produced in salmon coloured sporodochia and pseudopionnotes, 3-5-septate $23-40\times3{\cdot}5-4{\cdot}5\mu$. Aerial mycelium white at first, then covered by pionnotes. No sclerotia, no chlamydospores, substratum colourless to slightly brown.

Saprophyte on plant debris and in soil.

Measurements of the conidia are as follows :—

On hard oat agar, culture 14 days old :

3-septate 20% $20-30\times3{\cdot}5-4{\cdot}5$ $(25\times4{\cdot}3)$ μ.
4-septate 20% $22-35\times3{\cdot}5-4{\cdot}5$ $(29\times4{\cdot}3)$ μ.
5-septate 60% $27-40\times3{\cdot}7-4{\cdot}5$ $(33\times4{\cdot}4)$ μ.

On wood plug, culture 21 days old :

3-septate 40% $22-34\times3{\cdot}5-4{\cdot}5$ $(26\times4{\cdot}2)$ μ.
4-septate 20% $24-36\times3{\cdot}5-4{\cdot}5$ $(29\times4{\cdot}3)$ μ.
5-septate 40% $26-42\times3{\cdot}5-4{\cdot}5$ $(34\times4{\cdot}4)$ μ.

Cultures of this species have a pronounced tendency after continued culture on artificial media to produce great quantities of yellowish brown aerial mycelium, and to lose the power of forming typical sporodochia and pseudopionnotes. Such cultures approach very closely to those described by Sherbakoff as members of his section "*Ferruginosum*" (7) except that chlamydospores are absent. The conidia in such cultures are formed in small white groups on short branches of the aerial mycelium, and appear as white spots to the naked eye.

18.—**Fusarium stictoides** *Mont.*

Dur. & Mont. Flor. Alg. 1 : p. 334, Syll. Crypt. n. 1089. Saccardo Syll. Fung. 4 : 706. Wollenweber, Ber. d. Deutsch. Bot. Ges. 35 : 737. 1917.

Conidia of even diameter through most of their length, elliptically curved, curvature uniform, apex abruptly attenuated to slightly acute, base pedicellate, mostly 5–(7–) septate, averaging for 5-septate conidia 60 × 5μ produced in bright orange coloured sporodochia and in pseudopionnotes; aerial mycelium usually scanty, from white to same colour as conidia; chlamydospores few, intercalary; no sclerotia; substratum from almost colourless to brown shades.

Saprophyte on plant debris in Jamaica.

Measurements of the conidia on various media are as follows :—

On hard oat agar, culture 28 days old :

5-septate 80% 55—75 × 4·3—5 (63 × 4·7) μ.
6-septate 5% 60—80 × 4·5—5 (65 × 4·9) μ.
7-septate 15% 60—90 × 5 (72 × 5) μ.

On tomato stem plug, culture 21 days old :

5-septate 90% 48—65 × 4·3—5 (57 × 4·8) μ.
6-septate 8% 49—71 × 4·5—5·2 (60 × 4·9) μ.
7-septate 2% 60—72 × 5—5·2 (64 × 5·1) μ.

On wood plug, culture 21 days old :

5-septate 80% average 58 × 4·7 μ.
6-septate 15% average 61 × 5 μ.
7-septate 5% average 63 × 5 μ.

XIII.—Section **Elegans** Wr.

Wollenweber, Phytopath. 3 : 28. 1913. Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915. Wollenweber, Ber. d. Deut. Bot. Ges. 35 : 741. 1917.

" Microconidia usually simple, 5—12 × 2·0—3·5μ; macroconidia free, in tubercular sporodochia or confluent pionnotes, straight in some species, more or less sickle-shaped in others, end cells more curved than those in the centre, from acuminate to constricted base more or less pedicellate; blue sclerotia formed in many species. This section, otherwise very much like Lateritium, differs from the latter by having a large number of microconidia and terminal chlamydospores. Colour type vinaceous to violet." (13, p. 72.)

During the course of the present work special attention was given to this section of the genus. Over 300 strains were isolated belonging to this group, and all were studied in detail. Of these strains about 100 were isolated from the vascular bundles of banana plants suffering from the Wilt Disease (Panama Disease). All these isolations were made from those parts of the vascular system of affected plants which showed the earliest stages in the progressive discoloration of the bundles, which is one of the characteristics of this disease. The cultures thus obtained were again isolated as " single spore strains " and then compared with each other, and grouped according to their morphological characters as shown in artificial culture. These strains from the banana were classified into the following groups or " species " :

Group A.—Macroconidia of typical Elegans type; gradually pointed towards the apex, cylindrical in middle part; usually distinctly pedicellate, almost entirely 3-septate, averaging 26 × 4.3 (25 — 30 × 4 — 4.5) μ, produced in sporodochia and in pseudopion-

notes : 4–septate conidia rare in artificial culture, though produced in abundance in the sporodochia formed on the leafstalks of the host plant.

Microconidia usually in great excess in artificial culture, from almost cylindrical to curved, usually with rounded ends, occasionally somewhat pointed, of even diameter through most of length, 0– and 1– septate, 0–septate averaging 7 × 3.5μ, 1–septate averaging 13 × 3.7μ.

Conidia in mass from white to pink in colour ; aerial mycelium well developed, 3.5 to 5 mm. high, from white to pink in colour ; chlamydospores numerous, both terminal and intercalary ; substratum from colourless to vinaceous purple ; sclerotia constantly developed in cultures on potato tuber plugs ; dark blue to almost black in colour.

This group was found to comprise some 57 different strains of the present series, and was found in banana plants from every district in Jamaica where the wilt disease occurs.

Specimen measurements of conidia on various media are given below :—

On potato agar, culture 21 days old :

Conidia 0-septate 70% 3—12×2·5—4 (6·5×3·5) μ.
1-septate 10% 8—21×3—4 (12·5×3·5) μ.
3-septate 20% 19—31×3—4·5 (25×4) μ.

On hard potato agar, culture 14 days old :

0-septate 40% 3—13×2·5—4 (7×3·5) μ.
1-septate 15% 7—17×3—4 (13×3·7) μ.
3-septate 45% 18—29×3—4·5 (25×4·2) μ.

On wood plug, culture 21 days old :

0-septate 20% 3—12×2—3·8 (7·3×3·3) μ.
1-septate 15% 7—22×3—4 (14×3·8) μ.
3-septate 65% 21—34×3—4·2 (27×4) μ.

On tomato stem plug, culture 21 days old :

0-septate 20% 5—12×2·5—4 (8×3·5) μ.
1-septate 30% 9—19×3—4 (14×3·8) μ.
3-septate 50% 18—38×3·5—4·5 (29×4·2) μ.

Group B.—A small group of only 6 strains. This group differs from the cultures belonging to group A only in that sclerotia are never produced by the strains of this group, though grown repeatedly under the same conditions as the strains belonging to group A. During the 18 months that the 6 strains of this group were kept in culture for comparison with those of group A, sclerotia were never formed on any medium.

Measurements of the conidia on various media are as follows :—

On potato agar, culture 42 days old :

0-septate 60% 5—12×2·5—4 (7×3·5) μ.
1-septate 30% 7—23×3—4 (14·8×3·5) μ.
3-septate 10% 19—34×3—4·5 (28×4·2) μ.

On tomato stem plug, culture 21 days old :—

0-septate 40% 4—13×2·5—4 (7×3·4) μ.
1-septate 20% 9—21×3—4 (15×3·5) μ.
3-septate 40% 20—33×3·5—4·5 (27×4·4) μ.

On hard potato agar, culture 21 days old :

0-septate 30% 4·5—13×2·5—4 (7·3×3·5) μ.
1-septate 20% 8—20×3—4·2 (14·5×3·5) μ.
3-septate 50% 20—31×3·5—4·5 (26×4·3) μ.

Group C.—The strains of this group differ from those of group A in that their 3 septate conidia are noticeably broader towards the apex, and that the curvature in that region is greater than that in the middle and basal thirds of their length. Blue-black sclerotia are almost always produced in cultures on potato tuber plugs, and vary greatly in size in different strains, some of which produce large nodulose sclerotia up to 3 mm. in diameter. The 3-septate conidia are slightly larger than those of the preceding groups, averaging 30 × 4.3 (25 — 38 × 4 — 4.5)μ.

Measurements of the conidia of some of the 27 strains belonging to this group on various media are as follows :—

On potato agar, culture 56 days old, conidia from a large cream sporodochium :

0-septate 10% 6—10×3—4·5 (8×3·4) μ.
1-septate 5% 10—25×3—4·5 (16×3·8) μ.
3-septate 85% 22—42×3·5—4·7 (31×4·4) μ.

On tomato stem plug, conidia from a sporodochium in a culture 42 days old :

0-septate 20%.
1-septate 5%.
3-septate 65% 20—39×3·5—4·8 (29×4·3) μ.
4-septate 10% 26—50×4—5 (35×4·6) μ.

On potato agar, conidia from pseudopionnotes in culture 21 days old :

0-septate 65% 7—15×3—4 (8·5×3·5) μ.
1-septate 20% 11—24×3·5—4·5 (16×3·7) μ.
3-septate 15% 23—35×3·5—4·5 (29×4·3) μ.

On hard potato agar, conidia from sporodochium in culture 21 days old :

3-septate 75% 22—37×3·5—4·5 (31×4·2) μ.

Group D.—Differs from group A in the absence of sclerotia, and from groups B and C in its longer conidia, which are not produced in macroscopic sporodochia. The 3-septate conidia of this group average 35 × 4.2 (30 — 38 × 3.9 — 4.5) μ.

Specimen measurements of some of the 8 strains belonging to this group are as follows :—

On potato agar, culture 21 days old :

0-septate 80% 6—15×3—4·2 (8·5×3·5) μ.
1-septate 15% 12—25×3—4·5 (17·5×3·8) μ.
3-septate 5% 20—38×3·6—4·5 (31×4·3) μ.

On potato tuber plug, culture 35 days old :

0-septate 85% 4·5—15×3—4·5 (7·8×3·6) μ.
1-septate 12% 13—28×3·5—4·5 (18×4) μ.
3-septate 3% 27—39×3·7—4·5 (34×4·3) μ.

On tomato stem plug, culture 42 days old :

3-septate 20% 20—40×3·8—4·5 (34×4·2) μ.

On potato agar, culture 21 days old :

3-septate 40% 27—45×3·8—4·5 (38×4·3) μ.

On potato agar, culture 21 days old :

3-septate 5% 20—38×3·6—4·5 (31×4·3) μ.

Group E.—Differs from group A in having longer conidia and from group B in that sclerotia are developed on potato tuber plugs. Conidia 4-5-septate are much more common than in the strains classified in the foregoing groups. Typical microscopic sporodochia are developed. The conidia average for 3-septate 37 × 3·9μ; 4-septate 40 × 4·2μ and 5-septate 44 × 4·5μ. This is a small group of only 5 different strains.

Specimen measurements of the conidia of these strains on various media are given below :

On potato agar, culture 21 days old, conidia from pseudopionnotes :

0-septate 15% 7—16×3·2—4·5 (10×3·5) μ.
1-septate 15% 12—26×3·5—4·5 (18×3·8) μ.
3-septate 50% 25—40×3·5—4·7 (37×3·9) μ.
4-septate 10% 36—48×4—5 (42×4·5) μ.
5-septate 10% 36—50×4—5 (44×4·5) μ.

On potato tuber plug, conidia from sporodochium in culture 28 days old :

3-septate 40% 30—40×3·5—4·5 (37×4) μ.
4-septate 20% 36—46×4—5 (40×4·4) μ.
5-septate 30% 38—52×4—5 (44×4·5) μ.

On tomato stem plug, culture 18 days old :

3-septate 80% 30—40×3·7—4·5 (35×4·3) μ.
4-septate 15% 35—47×4—5 (41×4·4) μ.

On potato agar, conidia from pseudopionnotes in culture 21 days old :

3-septate 15% 25—40×3·5—4·5 (33×4·4) μ.
4-septate 5% 35—48×3·5—5 (38×4·5) μ.

All the cultures belonging to the above groups were isolated from the affected vascular bundles of banana plants suffering from the wilt disease or " Panama Disease." In order to test the pathogenicity of these cultures a number of typical strains was selected from each group, and inoculated into healthy banana plants. The latter were small " suckers " taken from a district which has never suffered from the wilt disease, and were washed in 4 per cent. formalin and planted in tubs. In some of these tubs the soil had previously been sterilised by passing through steam for one hour, as described by Brandes (2). The inoculations were made by growing the strains of *Fusarium* on a thin mush of banana tissue in large flasks, and emptying these in the soil around the roots of the suckers. Finally the cultures were covered with about 6 inches of soil. Control plants were kept, both in sterilised and in unsterilised soil. The inoculated plants in sterilised soil succumbed to the disease after a period of from 4 to 8 months, the control plants remaining quite healthy until dug up some months later for inspection. The inner tissues of these control plants on examination proved to be quite healthy, no sign of any disease being observed. The inoculated plants in the unsterilised soil remained healthy for a considerable time after those in the sterilised soil had succumbed to the disease, but finally after a period of 15 to 18 months some of them showed typical symptoms of the disease. The remaining inoculated plants were dug up and the rhizomes were examined internally for signs

of the disease. In every case the inoculated plants showed affection of the vascular system by the *Fusarium*, the extent varying from a slight discoloration of a few bundles on one side of the rhizome, to almost complete infection, extending into the leaf bases forming the " trunk " of the plants. On account of the prolonged shortage of water experienced by the plants, commencing about 6 months after planting, the progress of the disease was apparently much delayed ; the inoculated plants remaining after this time grew extremely slowly, and suffered considerably from lack of water. This is in accordance with field experience with the wilt disease, as during long periods of drought the progress of the disease is much slower than in rainy weather. There is no doubt, in the opinion of the writer, that had it been possible to allow the inoculated plants to remain longer, or to give them a more adequate water supply, they would have succumbed to the disease in exactly the same way as those planted in the sterilised soil. The symptoms shown by these plants inoculated and grown in ordinary unsterilised soil were typical of the earliest stages in attack of the banana plant by the disease, as observed in the field. The only difference between these two sets of inoculations in sterilised and unsterilised soil was that the progress of the disease in sterilised soil was much more rapid than in the unsterilised soil. Whether this is due to differences in the physical state of the soil when sterilised, or due to changes in the acidity, or whether it is due to the removal of other normal fungus and bacterial inhabitants of the soil by the process of sterilisation, the writer is unable to say. No differences were observed in the effect of the various strains of *Fusarium* used for the inoculations on the plants. All appeared to be equally parasitic in character, thus indicating that they must be considered biologically as a single species. This uniformity of the results of inoculation experiments with the members of the groups A to E above indicates that they must all be included under *Fusarium cubense*, E.F.Sm., which is defined as being the cause of the banana wilt disease. All the above strains were originally isolated from the vascular systems of diseased banana plants, and all of them used in the inoculation experiments on the banana gave positive results, causing the symptoms of the disease, the only difference found being in the time required by the various strains for complete infection of the vascular system of the inoculated plants. Under more suitable weather conditions all the strains would doubtless have given rise to the typical appearance of the disease on the inoculated plants very much sooner.

With regard to the above classification of these strains into the groups A to E, it must be mentioned that the boundaries of these groups are not sharply delimited, but rather that each represents a type and that in each group there are included strains that diverge from this type to a greater or less extent. Especially is this the case in those groups separated on a basis of the size of the conidia, as some strains were found to vary within considerable limits in the

average size of the conidia, even when grown for successive generations on the same medium.

In a recent paper by Gäumann (4) on the vascular diseases of *Musa* spp. in the Dutch East Indies, it is stated that the disease there prevalent, which corresponds closely in its symptoms with the true " Panama Disease " or " Banana Wilt " of Central America and the West Indies, is caused, not by a *Fusarium*, but by a bacterium. Gäumann expresses the opinion that the *Fusarium cubense* considered by the workers on the Panama Disease in the West Indies, etc., to be the cause of the disease, has not been proved such, and he compares it with the strains of *Fusarium* which he finds present in the vascular systems of plants affected with the similar disease which he describes in Java. He considers the species he finds present in this situation to be merely secondary invaders of the vascular systems of plants after attack by the primary bacterium. During the present series of isolations and inoculations the writer has found *Fusarium cubense* to be the sole invader of the vascular bundles which show the first stage in the progressive discoloration associated with the disease, and that bacteria are often completely absent from such bundles, only making their appearance some time later, when the bundles are considerably darker in colour. Portions of the vascular bundles of the leafbases of affected plants were cut out under sterile conditions, showing only the earliest stage in the discoloration of the tissues, and were plated out on potato agar in the usual way. Others were placed in tubes of sterile nutrient solutions, and incubated. In no case was any one bacterium found to be constant in its occurrence. In one series of isolations 30 tubes of nutrient broth were thus inoculated, and only 6 showed the presence of bacteria after a week's growth. These bacteria were isolated in pure culture, but none were found to correspond with that described by Gäumann (*Pseudomonas Musae*, Gäum.) as the cause of the wilt disease of the banana and other species of *Musa* in Java. All bacteria isolated by the writer from the vascular systems of bananas in Jamaica proved to be common saprophytes. None of those inoculated into the banana proved at all capable of invading healthy tissues and causing any symptoms similar to those of the wilt disease. Additional evidence against Gäumann's views on the true " Panama Disease " is afforded by the results of the many inoculation experiments which have been carried out by so many independent workers in the West Indies and Central America. In every case *Fusarium cubense* has proved capable of causing typical wilt symptoms when inoculated into healthy banana plants.

In addition to the 103 strains above described as isolated from the vascular tissues of banana plants suffering from the " Panama Disease ", 212 other strains belonging to the section *Elegans* were isolated from other sources. Many of these were isolated from

specimens of soil, " banana trash," and other plant debris. These strains were studied side by side with those described above, and classified into groups in a similar way. An exhaustive series of inoculation experiments was carried out with many of these strains on banana plants, using the same methods as those described above. In no case were any symptoms of wilt disease observed on the inoculated plants, and none of these strains appears to be at all pathogenic to the banana. This non-pathogenicity of these strains to the banana represents a constant and definite difference between them and those strains isolated from affected banana plants.

Group F.—The strains of this group proved to be morphologically identical with those of the group A above. No constant difference could be observed between the cultures of the two groups in spite of the most careful observation.

This group represents a very large series of different strains, 95 in number, isolated from many different sources. It is widely distributed throughout Jamaica, some of the strains being isolated as saprophytes in soil and on plant debris of all kinds, while others were isolated from the roots of various plants showing typical symptoms of wilt disease. Inoculations have not yet been carried out with these strains upon the hosts from which they were isolated, but it is possible that some of them may prove to be capable of attacking these hosts under certain climatic conditions.

The measurements of the conidia given for members of the Group A above apply equally well to the strains of this group.

Group G.—The strains of this group could not be distinguished from those of group B above in artificial cultures, but differed from them in not being at all pathogenic to the banana. This group contained only 12 different strains, all of which were isolated from soil specimens.

Group H.—This group of 72 different isolations proved identical in culture in the laboratory with the strains of group C above, but none of those used in inoculation experiments on banana proved capable of causing any symptoms of wilting. The members of this group are also common saprophytes in the soil, especially in the dryer parts of Jamaica, where this group often predominates largely in the *Fusarium* flora of the soil.

Group J.—This group of 23 different isolations proved identical in culture with the strains of group D above. All were isolated from soil specimens.

Group K.—This group of 13 isolations was morphologically similar to the groups C and H above, but the conidia are noticeably smaller than those of the strains belonging to these two groups, and are slightly broader towards the apex than in the other part of their length. The curvature of the conidia is greater towards the apex, and the average size for 3-septate conidia is $25 \times 4\mu$. None of these strains appears to be at all pathogenic to the banana. Most of them were isolated from soil specimens, but 6 were isolated from

specimens of dead and dying plants of sugar cane, being found present in the tissues of the roots.

Measurements of 3-septate conidia :

On potato tuber plug, culture 21 days old :

3-septate rare 18—26×3·5—4·5 (23×4) μ.

On tomato stem plug, culture 28 days old :

3-septate 40% 18—34×3—4·5 (26×4) μ.

On potato agar, culture 56 days old :

3-septate 20% 22—34×3—4·5 (26×4·2) μ.

On tomato stem plug, culture 42 days old :

3-septate 50% 20—30×4·2 (26×4·2) μ.

As was noted above, this detailed work on this section of the genus was originally undertaken in order to determine whether or not the organism causing the Panama Disease of the banana (*F. cubense* Smith, emend. Brandes) could be found present in soils other than those in the immediate vicinity of the roots of diseased banana plants. At an early stage in the investigation of this point it became necessary to evolve a method of differentiating this species from other closely related forms.

From the present work it becomes evident that the only possible test for this organism is that of inoculation into healthy banana plants. In other words, "*Fusarium cubense*" is a purely "biological" species, as distinct from the purely "morphological" species such as "*F. oxysporum*," etc., and cannot be diagnosed from its morphological characters, as shown in artificial culture.

During the course of his work on this problem of determining whether or not "*F. cubense*" is present in virgin soils, or in soils in districts where the bananas have not been affected with the wilt disease, the writer tested out some 50 different strains belonging to the groups F to K above, by inoculation into healthy banana plants, both in the manner described by Brandes (2) and also by direct inoculation into the tissues of the rhizome. In none of these experiments did the bananas show any symptom of the wilt disease, or even any local lesions on the roots or rhizomes. Consequently all the evidence from these trials tends to indicate that the "*Fusarium cubense*" of the Panama Disease is not present in any soil where the bananas are not attacked by the disease. This evidence is supported by the field experience of the Department of Agriculture in Jamaica, with their control measures devised for use against the disease, which are based upon the fundamental assumption that the disease is not present in "healthy" banana soils. Were this not the case it is probable that the history of the disease in Jamaica would have proved greatly different from what it has been up to the present. Although there is little doubt that climatic and other factors have a great influence upon the incidence and rate of spread of the disease, the history of the disease in Jamaica has been so vastly different from that in Central America that undoubtedly the energetic measures adopted here for the control of the disease have had a

great influence towards retarding the rate of spread. There is little question of any great difference in the actual virulence of the parasite having to be taken into account, as it has proved itself on several occasions capable of causing damage on a similar scale here in Jamaica to that in Central America.

The Classification of Section Elegans.

Wollenweber and his various co-workers have elaborated a classification of the whole genus *Fusarium* based on the morphological characters of the fungi as determined in artificial culture. In the case of the present section, however, the classification is much complicated by the fact that a large number of the fungi of this group are known to be pathogenic, causing wilt diseases of various plants. These pathogens are very similar to each other when grown in culture, and also to many of the saprophytic forms belonging to this same group. The search for suitable diagnoses of each of these pathogenic fungi has led to a very detailed examination of their morphological characters, with the result that the present diagnoses of the members of this section are based on extremely minute differences in their microscopic characters. The present position is still further complicated by the considerable range of variation shown by the different strains of each " species," and even by a single strain when grown repeatedly on the same medium and under apparently identical conditions.

Taking for example the " species " *F. cubense* E.F.Sm. and its variety *inodoratum* Brandes, these fungi are diagnosed as pathogenic to the banana (*Musa sapientum*), causing the Wilt or " Panama " Disease. All the fungi in the groups A to E above are included in this general biological diagnosis, yet in their morphological characters they show considerable divergence, even in some of the characters upon which Wollenweber has based the main division of the section into the two sub-sections *Orthoceras* and *Oxysporum*. Adopting his classification some of these strains of " *F. cubense* " should be placed in the former of these subsections, and others under various species of the latter.

It appears to the writer that the system of diagnosing " species " in the present section of this genus, by the selection of a morphological type as a basis for the erection of each species, is unsatisfactory, as it does not take into account the range of variation shown in such a " biological " species or unit as is formed by those strains which are capable of causing banana wilt. If, however, we endeavour to include all such strains in a single morphological species, by greatly widening the morphological diagnosis, we are confronted with another great difficulty, as we are then forced to include other strains having the same morphological characters, but distinct biologically as being non-pathogenic to the banana, and possibly either saprophytic in habit, or even pathogenic to other plants.

The most recent diagnosis of *F. cubense* is that given by Reinking and Wollenweber (13, p. 89), as follows :

" Macroconidia gradually attenuate toward the apex, end cell constricted, sickle-shaped, pedicellate, broader in the middle and generally more distinctly curved toward the apex, 3(4–5)-septate, typically 3-septate, $35 \times 4{\cdot}0$ ($17-51 \times 3{\cdot}0-4{\cdot}5$) μ ; also 2–5-septate, 2- and 4-septate being more common, 5-septate rare ; 4-septate $32-53 \times 3{\cdot}5-4{\cdot}5$ μ ; 5-septate $40-57 \times 3{\cdot}5-4{\cdot}75$ μ; sporodochia and pionnotes present ; microconidia ovoid or elongate, 0–1-septate, mostly 0-septate, $5-17 \times 2{\cdot}25-4{\cdot}5$ μ ; 1-septate $13-26 \times 3{\cdot}25-4{\cdot}0$ μ ; 2-septate $18-28 \times 3{\cdot}5-4{\cdot}5$ μ ; frequently produced in abundance with absence of macroconidia on young cultures ; chlamydospores abundant in old cultures, in mycelium (intercalary and terminal) in conidia, 0–1-septate 4–9 (–12) μ diameter, often catenulate, 0–septate, $4{\cdot}5-9 \times 4{\cdot}0-6{\cdot}25$ μ ; 1–septate $9-12 \times 4{\cdot}5-7{\cdot}25$ μ. Strong benzolic odour on rice."

The same authors note that two types of spores may be present, a long and narrow form from pionnotes, and a short and wide form from mycelium and older sporodochia, the latter being the more general type found, though for purposes of diagnosis they have selected the former type of spore.

In the paper quoted Reinking and Wollenweber distinguish those forms which they include under *F. oxysporum* var. *nicotianae* from *F. cubense* by such minor characters as the lack of a benzolic odour in rice cultures of the former, the more feeble development of sporodochia and pionnotes and of sclerotia in cultures of the latter, and by the absence of any evidence of pathogenicity to the banana in the case of the former. The production of a benzolic odour on rice is not always shown by cultures of *F. cubense*, such cultures being typical of the variety *inodoratum*, between which and *F. oxysporum* var. *nicotianae* the only difference is that of pathogenicity to the banana. Neither is the production of such an odour on rice limited to cultures pathogenic to the banana, as some strains isolated by the present writer, which showed no evidence of such pathogenic qualities, developed a strong odour when grown on rice.

At the same time these authors produce no evidence for including these strains under *F. oxysporum* var. *nicotianae*, which was originally diagnosed by Johnson as being the cause of the wilt disease of tobacco in the U.S.A. It appears to the present author that these strains might have been included under *F. cubense* with as much reason as under *F. oxysporum* var. *nicotianae*. Reinking and Wollenweber state that " it is evident that inoculation experiments are necessary for an accurate determination of the wilt-producing organisms " and that such a similarity as that indicated above shows " that there may be wild saprophytic forms of known pathogenic species." (13, p. 90).

These statements indicate that the authors referred to admit that it is impossible to distinguish between such a parasitic form as the organism producing a wilt of the banana and some of the closely related saprophytic forms. In consequence the morphological diagnoses of the various wilt-producing forms in this section are valueless as a method of separating them, and may be even somewhat misleading.

It appears to the writer that our present classification of this section of the genus, as elaborated by Wollenweber and his colleagues, serves merely as a means of separating into morphological "species" the saprophytic forms of the section, and cannot be applied to the parasitic strains, which cause vascular diseases of a large number of different plants. This separation of the saprophytic forms into such "morphological species" appears to be superfluous, and they might all be included under *F. oxysporum*, thereby much simplifying the nomenclature of this genus.

In the case of the pathogenic forms we are faced by another great deficiency from a classificatory standpoint, namely, the lack of any adequate work on the host range of each of these forms. It is possible that some of these forms may be cross-inoculable from one host to another, and work on this point is urgently needed. Also we have little knowledge at present of the conditions under which these parasitic and "semi-parasitic" forms are able to attack their various host plants.

In view of the above considerations the present author prefers to class all the organisms he has isolated belonging to this section of the genus as strains of *F. oxysporum*, the various strains showing among themselves considerable divergence both in morphological and physiological (biological) characters.

At the same time, in order to compare the present work with that of Wollenweber, a list is given below of the various "species" which are recognised by the latter, and which have been found by the writer in Jamaica:

19. **F. oxysporum** *Schlecht.*
20. **F. oxysporum** var. **nicotianae** (as defined by Reinking & Wollenweber, 13, p. 86).
21. **F. oxysporum** var. **nicotianae** *Johns.* (causing wilt of *Nicotiana tabacum*—rare).
22. **F. orthoceras** *App. & Wr.* (identified for me through the courtesy of Drs. Reinking & Wollenweber).
23. **F. orthoceras** var. **longius** (*Sherb.*) *Wr.*
24. **F. asclerotium** (*Sherb.*) *Wr.*
25. **F. lycopersici** (*Sacc.*) *Wr.* (causing wilt of *Solanum lycopersicum*—rare).
26. **F. cubense** *E. F. Sm.*
27. **F. cubense** var. **inodoratum** *Brandes.*

F. cubense and its variety *inodoratum* cause the Wilt or Panama Disease of the banana (*Musa sapientum*) and the plantain (*Musa paradisiaca*) and are found in most of the banana growing areas in Jamaica.

28. F. **aurantiacum** (*Lk.*) *Sacc. emend. Wr.* (found in soil and on the roots of diseased *Saccharum officinarum*).

The fungi of this group are common organisms in the soil in Jamaica, and from almost every soil isolation made organisms

satisfying one or other of the diagnoses of the "species" enumerated above could be isolated. These fungi are also common on all decaying and diseased vegetable matter, usually growing as secondary saprophytes, following on the pathogenic fungi causing the disease in the case of diseased plants. Several have been found as secondary invaders in the vascular tissues of the "bulb" (rhizome) of bananas affected with wilt disease, following on the *Fusarium cubense* causing the disease. The latter can usually be isolated in pure culture from those parts of the vascular system of affected plants which show the earliest stages in the progressive discoloration of the vascular bundles due to the disease. At later stages in the discoloration other organisms are found present, usually other members of this same group, section Elegans, of *Fusarium*. Subsequently other Fusaria enter the diseased bundles as well as members of other genera.

The other parasitic organisms mentioned above, namely, *F. oxysporum* var. *nicotianae* (sensu stricto) and *F. lycopersici* are only occasionally met with in Jamaica.

XIV.—Section **Martiella** Wr.

Wollenweber, Phytopathology 3 : 30. 1913. Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915. Wollenweber, Ber. d. Deut. Bot. Ges. 35 : 738. 1917. Wollenweber, Sherbakoff et al. Journ. Agr. Res. 30 : 833, 1925.

This section is thus diagnosed by Wollenweber :

"Macroconidia dorsiventral, spindle to sickle-shaped, apex more or less rounded, base more or less subpedicellate ; microconidia oval to oblong, mostly o-septate ; sporodochia and pionnotes present, white, pale ochre or golden ; stroma greenish to blue or almost black ; chlamydospores terminal, intercalary, 1-celled, 2-celled, catenulate or in heaps. Imperfect stage of the group Hypocreales, section Pseudomartiella." (13, p. 102.)

The strains belonging to this section are easy to recognise as such, but the identification of the various species and varieties within the group is a matter of extreme difficulty. The size of the spores and the number of septa vary considerably, even in a single strain of the group ; and these are the characters upon which the separation into species is chiefly based.

Wollenweber and Sherbakoff have made varieties and even species which could have been avoided had they allowed their species to become slightly more comprehensive, and the characters on which these varieties are separated are, in the experience of the writer, not sufficiently stable. The species erected by these workers merge gradually one into another through a large series of forms which are more or less intermediates, and which have, in some cases, been considered as distinct varieties of the various species.

29. **Fusarium solani** (*Mart. pr. p.*) *App. & Wr.* var. **minus** *Wr.*

Wollenweber, Ann. Myc. 15 : 55. 1917.

Wollenweber & Reinking diagnose this as follows :

"Macroconidia 3-septate, $27-33 \times 4{\cdot}25-5{\cdot}0$ μ ; chlamydospores terminal, intercalary, single, catenulate or in heaps, sometimes rugulose, 7–8-μ diam. For other characters see *F. solani*." (13, p. 102.)

This has been found in Jamaica by the writer in soil and on the roots of diseased sugarcane (*Saccharum officinarum*) together with *F. aurantiacum*. It is quite common as a saprophyte on decaying banana material.

The cultures of this fungus were identified for me through the courtesy of Drs. Reinking and Wollenweber.

30. **Fusarium solani** (*Mart. pr. p.*) *App. & Wr.*

Appel & Wollenweber, Arb. K. Biol. Anst. Land.-u. Forstw. 8 : 65. 1910. Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915. Carpenter, Journ. Agr. Res. 5 : 204. 1915. Wollenweber, Ann. Myc. 15 : 25. 1917.

" Macroconidia scattered in mycelium or in false heads, in sporodochia or pionnotes, spindle shaped or slightly curved, typically broader in upper half of length, rounded to slightly constricted apex, slightly pedicellate or not at all, 1–5-septate, typically 3-septate 30—40 × 5·0—6·0 (25—45 × 4·5—6·5) μ fewer 2– and 4-septate: 1-septate 15 × 4·0 μ; 5-septate 42—48 × 6 μ; conidial mass brownish white, in older cultures light brown and sometimes with green or greenish blue; plectenchymata sometimes greenish blue in older cultures and white or brownish white in younger; chlamydospores terminal intercalary, in mycelium and conidia, 1-celled, spherical or pear-shaped, 8·5 × 8 μ, 2-celled 12 × 7·75μ, less seldom in chains or heaps, smooth, sometimes definitely rugose.

" *F. Solani* has a broad type of conidia." (13, p. 106.)

In Jamaica the present author has isolated this fungus from soil, where it appears to be fairly common in occurrence, and also from banana debris.

31. **Fusarium Martii** *App. & Wr.* var. **minus** *Sherb.*

Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915. Wollenweber, Ann. Myc. 15 : 26. 1917.

Sherbakoff describes this variety as follows:

" Differs from *F. Martii* and *F. Martii* var. *viride* by having smaller, 3-septate conidia 36·7 × 4·8 (30—44 × 4·55—5·1) μ, usually prominent development of plectenchymic, wart-like stromata, and fewer and larger sporodochia. Colour of substratum, on Potato agar rich in glucose, from light gray to drab and dark olive-buff, with a fuscous-coloured spot at the point of inoculation."

This variety is the commonest member of this section to be found in Jamaica, and is present in most soils, especially in the wetter districts. It is common on all kinds of vegetable debris.

Several of the writer's cultures differed from the above diagnosis in that no sclerotia were developed in artificial culture, but in other respects they satisfied Sherbakoff's diagnosis, so that they have been included under this variety.

32. **Fusarium Martii** *App. & Wr.*

Appel & Wollenweber, Arb. K. Biol. Anst. Land.-u. Forstw. 8 : 78. 1910. Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915. Wollenweber, Ann. Myc. 15 : 25. 1917.

Wollenweber gives the following description:

" Conidia scattered in the mycelium, in false heads, or in sporodochia or pionnotes, normal conidia much longer than in *F. solani*, straight in the middle or only slightly curved, curve more pronounced at the ends, especially the apex, dorsal and ventral sides often almost parallel except at the apex;

3–4-septate, 44—60×4·75—5·5 (39—70×4·5—6·0) μ, less frequently 5-septate 54—62×4·5—5·75 μ; 6-septate up to 82×5·0 μ, colour of conidial masses between brownish white and light brown, and through the mingling of the greenish blue plectenchymata, the pionnotes may assume a gray, bluish gray or brown to black colour; plectenchymatic stroma little or lacking; chlamydospores as in *F. solani*."

Found in Jamaica on tubers of *Solanum tuberosum* and on the surface of a partially burnt banana rhizome, and also very occasionally in soil.

33. **Fusarium eumartii** *Carp.*

Carpenter Journ. Agr. Research 5: 204. 1915.

Carpenter's description of this species is as follows:

"Agrees with Appel & Wollenweber's diagnosis of *F. Martii* except in certain details of the conidia. The latter are higher septate and have a somewhat larger average size. Normally 4–6-septate, averaging 54 to 75×5·5 to 6·6 μ (limits: 50—80×5—7·2 μ) . . . . .

The conidial colour fluctuates between brownish white and bright brown; by infiltration of the greenish blue plectenchymatic pigment the conidial mass becomes gray, blue-green to brown and a dark mixed colour. The plectenchymatic stroma is weakly developed or lacking, and therefore the pionnotes lies naked on the substratum. The chlamydospores, 7–10 μ in diameter, agree with those in other species of this section."

The present writer has only once isolated a strain belonging here, from a leafspot on *Solanum torvum*, where it was probably a secondary saprophyte following on the *Cercospora* causing the spot. It agrees closely with the above description, and is easily distinguishable from the other species of this section found here, by the higher septation and larger size of the conidia.

34. **Fusarium radicicola** *Wr.*

Wollenweber, Journ. Agric. Res. 2: 257. 1914. Sherbakoff, Cornell Agr. Exp. Sta. Mem. 6. 1915. Carpenter, Journ. Agric. Res. 5: 205. 1915. Wollenweber, Ann. Myc. 15: 26. 1917.

Reinking & Wollenweber thus describe this species:

"Conidia comparatively slender, spindle to sickle-shaped, slightly constricted at both ends, apiculate to subpedicellate at the base, normally 3-septate, may occur scattered in sporodochia or pionnotes, averaging 30—45×3·75—5μ; 25% of the total number may be 4-septate; 5% may be 5-septate and average 40—59×4·0—5·25 μ; chlamydospores 7—10 μ, agree with those of other species of the section Martiella." (13, p. 122.)

In Jamaica this species has been isolated from soil, and Carpenter (3, p. 206) mentions that he had received a culture of this species from Mr. S. F. Ashby, isolated from *Musa sapientum* in Jamaica.

35. **Fusarium javanicum** *Koord.*

Koorders, Verh. Kon. Akad. Wetensch. Amsterdam II, 13: 247. 1907. Saccardo, Syll. Fung. 22: 1482. 1913. Wollenweber Ann. Myc. 15: 26, 1917. Ber. d. Deut. Bot. Ges. 35: 742. 1917. Reinking & Wollenweber, Fusaria in Relation to Banana Cultivations. United Fruit Co. Boston. 1925.

"Conidia scattered, in sporodochia and pionnotes, 3–4–5-septate 43—54×4·5—5·0 μ; 5-septate 49—54×4·5—5·4 μ; base subpedicellate, apex cell longer and less curved and more pointed than *F. striatum*, sometimes acute,

approaching sickle-shaped; chlamydospores 1–2-celled, terminal and intercalary; mycelium white to cartridge buff; conidial masses cream-buff, olive-ochre, or at times greenish." (13, p. 128.)

Isolated only once from a specimen of soil from Buff Bay, Portland.

Although the writer has separated the strains of this section into the above species, he is of opinion that future workers on this genus will modify the present classification and unite several of the "species" recognised by Wollenweber into a single more comprehensive species, taking into consideration the many forms which are more or less intermediate in characters between the types which are at present elevated into "species" and "varieties." Most of the forms belonging to this section of the genus are either of saprophytic habit or are wound parasites, and in the writer's opinion the present classification merely adds to the difficulty of identifying these organisms, by unnecessarily multiplying the number of species in the group. I have not studied the organisms of this section in the same detail as in the case of those isolations belonging to the section Elegans, and in the present instance I have followed the classification of Wollenweber and his co-workers as far as possible.

Hypocreales.

36. **Hypomyces ipomoeae** (*Hals.*) *Wr.*

Wollenweber, Phytopathology 3: 34. 1913; Journ. Agr. Res. 2: 270. 1914; Ann. Myc. 15: 8. 1917; Ang. Bot. Zeit. Erf. Nutzpfl. 6: 300. 1924.

Reinking and Wollenweber give the following diagnosis:

"Perithecial stage: Perithecia scattered or gregarious, free on the surface of the host, as well as embedded in mycelium or on a distinct plectenchymatic stroma, ovoid, subconical, sub-flask-shaped; averaging 225—375 × 175—300μ. Peridium strongly verrucose, owing to protuberance-like projections of cell groups, red to reddish-brown, except the almost colourless conical beak. A few paraphyses line the inner wall of the throat from the ascus ball to the ostiolum. Asci up to over 100 in each perithecium, intermixed with a few more celluled paraphyses. Ascospores 8, in one row or irregularly in 2 rows, 2–celled ovoid to ellipsoidal, with wrinkled exospore, in mass brownish white; 1-septate, average size 10—13 × 4·5—6·0 μ, under moist over-ripe conditions slightly constricted at septum.

Conidial stage: Conidia scattered in sporodochia or pionnotes of nearly cylindrical shape at the septal zone, slightly pointed and curved at the ends, base pedicellate without a distinct heel. Conidia 3–5-septate; 3-septate 30—45 × 3·75—5·0 μ; 5-septate 45—70 × 4·25—5·5 μ. Of the total number 30% may be 6-septate, 10% may be 7-septate with an average size up to 70 × 6 μ. In young moist and hunger stages unicellular conidia occur, averaging 6—12 × 3·0—4·75 μ. Colour of conidial masses brownish white, occasionally impregnated with blue, a mycelium colour, especially found in the plectenchyma. Conidiophores verticillately branched. Chlamydospores globose or ellipsoidal, terminal and intercalated, mostly unicellular and scattered, average diameter 7—10 μ." (13, p. 136.)

In Jamaica this form has been isolated from soil, from a knot on *Citrus* twigs caused by *Sphaeropsis tumefaciens*, where the present fungus was apparently a secondary invader of the tissues, and from the cut surface of a banana rhizome at Catadupa, which had been exposed under damp conditions for a few days.

During the course of the present work the writer has been struck by the defects of the present system of classification of this genus, as given by previous workers. Up to the present it seems that the conception of a single species in this group of fungi has been kept too rigid, and does not allow a sufficient range of variability within the species. Especially is this the case in the sections *Elegans* and *Martiella*. The organisms of the former include many parasites of crop plants, and the workers on this group have endeavoured by a minutely detailed examination of the characters of these fungi grown in culture under as far as possible closely specified conditions, to separate these organisms from each other on morphological characters, which necessarily show extremely minute differences, if indeed, any at all, between the various strains of the group. Not only are these differences between the so-called "species" so minute, but at the same time each organism shows such a great range of variability in its morphological characters that the differences used to separate the various "species" are almost negligible by comparison. This point has been discussed above in the remarks on the section *Elegans*, and in the present work all strains of this group are considered as belonging to a single species, which shows a large range of variation, both in morphological and in biological characters. These remarks apply with almost equal force to the section *Martiella*.

It appears to me that much would be gained, and much labour spared, were the various sections of the genus which have been erected by Wollenweber and his colleagues to be considered as species rather than sections of the genus, and then the various species at present included in these sections could be regarded as forms of these large species which show a slight variation from a central type. Many of the present "species" in the section *Elegans* have been erected on more or less purely pathological characters, and morphologically are included in other species of the same group. The above suggestion would remedy this state of affairs, and seems to be the only solution to the present difficulty. This need for a less rigid morphological basis for the erection of species is not confined to this genus, but is felt in many other of the larger genera, especially in the *Hyphomycetes*, and in the *Fungi Imperfecti* generally. It was shown for the genus *Cladosporium* by Brooks and the writer (Trans. Brit. Myc. Soc. 8: 113. 1923).

LITERATURE CITED.

1. Appel & Wollenweber. Grundlagen einer monographie der Gattung *Fusarium*. Arb. K. biol. Anst. Land-. u. Forstw. 8: 1910.

2. Brandes, E. W. Banana Wilt. Phytopathology, 9: 339. 1919.

3. Carpenter, C. W. Some potato tuber rots caused by species of *Fusarium*. Journ. Agr. Res. 5: 183. 1915.

4. Gäumann, E. Over een Backvelle vaat bundelziekte der bananen in Nederlandsch-Indie. Meded. Inst. voor Plantenziekten, 48, 1921. (Abstract in Rev. of App. Myc. 1: 223. 1922)

5. Morris & Nutting. Identification of certain species of *Fusarium* from potato tubers in Montana. Journ. Agr. Res. 24: 339. 1923.

6. Saccardo, P. Sylloge Fungorum.

7. Sherbakoff, C. D. *Fusaria* of Potatoes. Cornell Agr. Exp. Sta. Mem. 6. 1915.

8. Wollenweber, H. W. Studies on the *Fusarium* problem. Phytopathology, 3 : 24. 1913.

9. Wollenweber, H. W. *Ramularia, Mycosphaerella,* etc. Phytopathology, 3: 197. 1913.

10. Wollenweber, H. W. Identification of species of *Fusarium* on the Sweet Potato. Journ. Agr. Res. 2: 251. 1914.

11. Wollenweber, H. W. Conspectus analyticae Fusariorum. Ber. d. Deutsch. Bot. Ges. 35:732. 1917.

12. Wollenweber, H. W. Fusaria autographice delineata. Ann. Myc. 15: 1. 1917.

13. Reinking, O. A. & Wollenweber, H. W. *Fusaria* in Relation to Banana Cultivations. United Fruit Co. Boston, 1925 (Mimeographed).

14. Wollenweber & Reinking. Aliquot *Fusaria* tropicalia nova vel revisa. Phytopathology, 15: 155. 1925.

15. Wollenweber, Sherbakoff, Reinking, Johann & Bailey. Fundamentals for taxonomic studies of Fusarium. Journ. Agr. Res. 30: 833. 1925.

XXXV.—NEW POLYSTACHYAS. F. Kraenzlin.

The monograph of *Polystachya* published in *Fedde Repert.* Beiheft xxxix had already been sent to the printer when the material described in this paper arrived. It was impossible to recall the manuscript, but on the other hand it would have been even more inconvenient to wait until the present paper had been published. I resolved therefore to publish these new species as a separate paper in the *Kew Bulletin*. The names of the sections written in square brackets are the same as those I have proposed in the Monograph, while the notes concerning the closer affinities will make it easy to bring the new species into their proper places in the system.

Polystachya subcorymbosa *Kraenzl.* n. sp., [*Caulescentes*]; differt ab omnibus speciebus adhuc descriptis inflorescentia apice corymbosa paulum elongata. Recedit a ceteris *Caulescentibus* floribus erectis longe pedicellatis. Nulli ceterum affinior.

Caulis gracilis, pars quae praestat 16 cm. longa, tenuis; internodia 7 cm. longa, vaginis griseis 3.5 cm. longis vestita. *Folia* linearia, longe acuminata, ad 11 cm. longa, 6 mm. lata, sensim decrescentia, supremum 3.5 cm. longa. *Scapus* teres vel vix compressus, glaber vel sparsissime puberulus; inflorescentia simplex,

subcorymbosa, floribus supremis subumbellatis aequialte congestis, ovaria longe (8–10 mm.) pedicellata; bracteae ovato-triangulae, acuminatae, 2 mm. longae. *Sepalum dorsale* late oblongum, acutum, 3 mm. longum; sepala lateralia ad 6 mm. longa, late oblonga, acuta, mentum galeatum, obtusum, quam pars antica sublongius formantia. *Petala* obovata, obtusa. *Labelli* lobi laterales ligulati, obtusi, divergentes; lobus intermedius cuneatim dilatatus, antice retusus vel subbilobulus, pulvinar maximum ab ipsa basi ad apicem lobi intermedii dense villosum, exceptis margine et lobis lateralibus calvis. *Gynostemium* generis perbreve. *Flores* luteo-albi.

Country of origin unknown. Cultivated at the Royal Botanic Gardens, Kew.

A species of a very slender caulescent habit with distant very narrow leaves showing no special feature. The short few-flowered inflorescence is nearly an umbel, the flowers which have rather long nearly equal pedicels being crowded in a singular manner that I have never seen in any of the numerous specimens I have previously examined. The flowers are rather small, of no beauty at all, the only character of any interest being the enormous cushion of velvety hairs beginning at the base of the lip and extending to the top of it. It is to be regretted that there is no information stating by whom and from where the specimen was sent to the Royal Gardens.

Polystachya graminoides *Kraenzl.* n. sp., [*Caulescentes*]; differt a *P. oligophylla* Schlechter cui certe proxima foliis anguste linearibus multo longioribus, panicula longiore pluriramosa, mento vel galea sepalorum lateralium brevissimo rotundato neque in pileum producto, lobo labelli intermedio oblongo obtuso, disco omnino glabro.

Planta elata, paucifoliata, 40–45 cm. alta (pars basilaris deest); internodia 3–6.5 cm. longa. *Foliorum* vaginae arctae; laminae gramineae, 10–25 cm. longae, longe acuminatae, 5–8 mm. latae, satis durae, tenacissimae, supremae paniculam superantes, summum caulem versus in vaginas 2 vel 3 angustas, acuminatas, decrescentes; vagina suprema basin paniculae amplectens. *Panicula* ad 8 cm. longa, rami 4–6, per totam longitudinem dense floriferi, tota panicula igitur multiflora; flores parvi, subglobosi, extus glabri; bracteae circiter 1 mm. longae, triangulae, acutae. *Sepalum dorsale* late triangulo-ovatum, acutum, concavum, circiter 1 mm. longum; sepala lateralia latissime ovata, profunde concava, obtuse acutata, vix mentum subglobosum formantia, 1.5 mm. longa, basi 1.5 mm. lata, omnia (sicca scil.) clathrata. *Petala* subbreviora, obtusa, tenerrima. *Labellum* a latere visum sigmoideum in florem reflexum; lobi laterales late lineares, obtusi, intermedio longiores; lobus intermedius latior, brevior, cum lineis 3 paulo crassioribus, discus ceterum glaber et ecallosus, totum labellum 1.5 mm. longum, inter lobos laterales 1.5 mm. latum. *Capsulae* mihi non visae.—Fl. Octobri.

Tropical Africa. Uganda: Mukono, common in the Victoria Nyanza region, *T. D. Maitland*.

From its flowers only, the species would be placed among the *Calluniflorae*, but in its habit, leaves and inflorescence it is totally different. The nearest species is certainly *P. oligophylla* Schlechter, while from the structure of the lip *P. stauroglossa* Kraenzl. is also closely allied. On account of the total lack of hairs on the disk of the lip the flowers of this species are certainly less attractive to insects and thus the total absence of capsules is explicable.

Polystachya candida *Kraenzl.* n. sp., [*Eupolystachyae*]; differt a *P. obanensi* Rendle pseudobulbis contiguis curvulis, spica densiore, labello etiam latiore, callo mediano crassissimo.

Rhizoma repens (ascendens). *Pseudobulbi* curvuli, pauciarticulati, in collum brevem terminati, ad 3.5 cm. alti, 2 vel 3 internodiis compositi, basi (sicci scil.) 5-6 mm. diametro. *Folia* non praestant. *Scapi* summitas tantum adest cum inflorescentiis 2, altera racemosa, altera paniculata, pauciramosa, scapus ceterum glaber, superne (rhachis) sparsissime setulosus; flores circiter 20, albi, sicci tamen nigri; bracteae triangulae, acuminatae, ad 2 mm. longae vel vix longiores; pedicelli cum ovariis (triquetris?) 6–7 mm. longi. *Sepalum dorsale* ovatum, obtuse acutatum, profunde concavum, 4 mm. longum, basi 3 mm. latum, satis difficile explanandum; sepala lateralia late triangula, valde concava, breviter acutata, mentum ample saccatum subduplex efficientia, ad 5 mm. longa, 3 mm. lata; omnia 3 textura satis firma, dense reticulata. *Petala* lineari-spathulata, breviter apiculata, multo teneriora, vix ultra 2 mm. longa. *Labellum* toto ambitu rhombeum; lobi laterales vix sejuncti (si mavis latissime obtrianguli) antice retusi, et lobus intermedius triangulus valde obtuse acutatus, apex labelli obtusus, totum labellum 3 mm. longum, expansum 4 mm. latum, callus in disco ceterum glabro crassissimus a basi ad 1/3 totius longitudinis decurrens.

Probably a native of eastern tropical Africa; cultivated in England.

Of this species there are in the Kew Herbarium only two specimens which flowered in the houses of the Royal Botanic Gardens in the years 1906 and 1907, and were dried presumably by the late Mr. R. A. Rolfe. There is no information about the country of origin. The spikes and especially the lip of the flowers resemble those of *P. obanensis* Rendle. The flowers are said to have been white.

Polystachya lepidantha *Kraenzl.* n. sp., [*Eupolystachyae* II. *Dolichophyllae*.]; differt a *P. Buchanani* Rolfe (et ab omnibus aliis) floribus intus ubique lepidotis, labelli lobis lateralibus latioribus obtusis ceterum illi speciei valde affinis.

Specimen unicum mancum, adest folium 1 apice refractum et scapus. *Folium* e basi vaginante oblongum, pars quae praestat ad 20 cm. longa (totum certe ad 25 cm. longum), 4.8 cm. latum.

Scapi pars quae praestat 25 cm. longa, stricta, apice nutans, vaginis griseo-albis dense imbricantibus apicem usque vestita; racemuli ad 7, breves, nutantes, densiflori e vaginis erumpentes, ad 2 cm. longi; rhachis brevi-setosa; bracteae triangulae, ovaria aequantes, acuminatae, circiter 2 mm. longae; ovaria glabra. *Sepalum dorsale* ovatum, acutum, concavum, 3 mm. longum, basi 1.5 mm. latum; sepala lateralia triangula, leviter curvata, acuta, mentum parti anticae aequilongum obtusum formantia, 5.5 mm. longa, 3 mm. lata, intus ubique dense albido-lepidota. *Petala* linearia, antice paululum latiora, breve obtuseque acutata, 3 mm. longa. *Labellum* sessile, e basi cuneata trilobum; lobi laterales oblique oblongi, obtusi; lobus intermedius subquadratus, retusus, latior quam longus, leviter crenulatus, cum callo satis alto a basi medium discum usque decurrente parce farinosum, totum 5 mm. longum, inter lobos laterales 4 mm. latum. *Anthera* manifeste cristata; pollinia magna. *Flores* viridi-lutei.—Fl. Februario.

Tropical Africa. Uganda: epiphytic in forests at 1200 m., *Snowden* 726.

The flowers are densely covered inside with silvery scales, a character not seen in any of the nearly 200 species I have examined. In its general appearance the plant resembles medium sized specimens of *P. Buchanani* Rolfe or *P. Lettowiana* Kraenzl.

Polystachya Johnsonii *Kraenzl.* n. sp. [*Eupolystachyae, Rufinulae*]; differt a *P. nitidula* Rchb. f. cui proxima foliis anguste linearibus obtusis rotundatis, labelli lobis lateralibus etsi parvis bene evolutis liberis.

Caulis basi vix incrassatus, internodiis 3 vel 4 compositus, arcte albido-vaginatus, tota planta cum inflorescentia ultra 30 cm. alta. *Folia* linearia, basi breviter complicata, apice obtusa, oblique bilobula, ad 15 cm. longa, 10–12 mm. lata. *Scapus* tenuis, vaginis albidis arcte amplectantibus acutis apicem usque tunicatus, inflorescentia racemulis 6 (supremo apicali subevanido) secundis densi et multifloris 3 cm. longis composita; rhachis breviter setosa; bracteae circiter 0.5 mm. longae, triangulae, acutae; ovaria 1.5 mm. longa. *Sepalum dorsale* oblongum, acutum, 1 mm. longum, petala linearia aequilongum; sepala lateralia triangula, acuta, 3 mm. longa, medio 2 mm. lata, mentum breve, pro flore minuto amplum, obtusum formantia. *Labellum* e basi cuneato-dilatatum; lobi laterales in medio labello parvi, tamen manifesti divergentes; lobus intermedius suborbicularis, acutus, callus minutus in basi disci dense puberuli; totum labellum 2.5 mm. longum, inter lobos laterales vix 2 mm. latum. *Flores* intense lutei.

Tropical Africa. Gold Coast: Aquapim Hills, epiphytic on high trees, *W. H. Johnson* 588.

A species with unusually small flowers on nodding flower stalks. The plant differs from *P. nitidula* Rchb. f. in characters only to be seen by a very accurate examination.

Polystachya fallax *Kraenzl.* n. sp., [*Cultriformes* s. *Monophyllae*]; differt a *P. monophylla* Schlechter cui simillima videtur inflorescentia breviore pauciflora, floribus majoribus, petalis lanceolatis acuminatis, labelli lobis lateralibus distinctis rhombeis, lobo intermedio lanceolato acuminato.

Rhizoma repens, radicibus crebris longis obsitum, oblique ascendens. *Caules* pseudobulbosi, circiter 1.5 cm. distantes, elongato-conici, profunde sulcati, cataphyllis 2 vel 3 vaginantibus pallidis scariosis omnino tecti, ad 3.5 cm. longi, basi sub anthesi 5 mm. post anthesin ad 8 mm. diametro. *Folium* unicum basi breviter plicatum, strictum, lineare, apice obtusum, 10–11 cm. longum, 8–10 mm. latum. *Scapus* vix semilongus (ad 4 cm.), vagina longiuscula albida vestitus, 3–4-florus, anceps, glaber; bracteae brevissimae, triangulae, acutae, 1.5 mm. longae et basi 1.5 mm. latae. *Sepalum dorsale* lanceolatum, acuminatum, 1 cm. longum, medio 2.5 mm. latum; sepala lateralia subfalcata, anguste triangula, acuminata, mentum leviter curvatum, obtusum formantia, 1.2 cm. longa (mentum 5 mm.), basi vix 3 mm. lata. *Petala* lineari-lanceolata, acuminata, 8–9 mm. longa. *Labellum* e basi cuneata sensim dilatatum; lobi laterales rhombei; lobus intermedius lanceolatus, acuminatus, callus a basi dimidium usque decurrens apice dilatatus, obscurissime trilobus, totum labellum 8–9 mm. longum. *Gynostemium* pro flore longum, anthera cristata.

Tropical Africa. Uganda: Toro, Mpanga River at 1500 m. *M. T. Dawe* 539.

I regret that the description of the flower is not throughout satisfactory, the only flower I had being partly injured by an insect. It is a strange fact, that this true *Polystachya* resembles exactly in habit and size *Epidendrum paleaceum* Reichb. f. of Central American origin (cf. the figure of this plant in Sauders Refugium botanicum II. tab. 87.).

Polystachya coelogynochila *Kraenzl.* n. sp., [*Cultriformes* s. *Monophyllae*]; differt a *P. poikilantha* Kraenzl. floribus majoribus, mento valde evoluto, labello e basi latissima modice dilatato margine undulato cristis 5 erectis denticulatis praedito antice retuso.

Caulis cujus summitas tantum adest, mihi non visus. *Folium* basi cordatum, obovato-ligulatum, obtuse acutatum, 12.5 cm. longum, antice 2.5 cm. latum. *Inflorescentia* (imperfecta) folio brevior, vaginis 1 vel 2 vestita, racemosa, pauciflora; rhachis tenuis, glabra, nutans; bracteae triangulae, acutae, vix 1 mm. longae; pedicelli cum ovariis glabri, curvuli, 1 cm. longi. *Sepalum dorsale* anguste oblongo-lanceolatum, concavum, acutum, 1 cm. longum, cum petalis aequilongis paulo angustioribus linearibus arcte convergens; sepala lateralia falcata, triangula, acuminata, 1.2 cm. longa, medio 3.5 mm. lata, postice mentum obtusum, 5 mm. longum, leviter bisaccatum formantia. *Labellum*

simplex, toto ambitu late oblongum, e basi lata modice dilatatum, antice retusum, fere rectilineum, toto margine undulatum, in tertia antica leviter denticulatum, cum cristis 5 valde undulatis totum per discum magna pro parte parallelis vel vix divergentibus et antice denuo convergentibus, totum labellum 1 cm. longum et quo latissimum 5 mm. latum. *Gynostemium* inusitate (5–6 mm.) longum, margine foveae stigmaticae utrinque dente membranaceo aucto ; pes gynostemii 7 mm. longus. De colore nil constat.

Tropical Africa. Collected in East Africa and grown by Mr. Alfred Cholmlys, Rillington (Yorkshire).

A most remarkable species. The specimen is cut off a little below the insertion of the only leaf and therefore there can be no doubt that the species belongs to the Section *Cultriformes*. In the structure of the lip it is unique among all Polystachyas I have met with, the 5 crests being exactly the same as those found so often in the flowers of *Coelogyne*. There are 2 flower-stalks in the specimens both of the same weak, nodding description, and bearing about 6 flowers. The column is unusually long and slender and the stigmatic cavity is provided on both sides with a membranous tooth.

Polystachya Pseudo-Disa *Kraenzl.* n. sp., [*Elasticae*]; differt a *P. elastica* Lindl. scapo multo altiore, floribus minoribus, sepalis ante apicem cornu minuto praeditis, hypochilio alte carinato.

Folia et radices desiderantur. *Scapus* 30 ad ultra 40 cm. altus, strictus, vaginis compluribus albidis imbricantibus omnino tectus; vaginae arcte appressae, acuminatae, infimae 1–1.5 cm. longae supremae ad 5 cm. decrescentes. *Flores* sessiles, in spicas 8–15 cm. longas, densiusculas, cylindraceas, multifloras dispositi, illas *Disae* cujusdam ex affinitate *D. polygonoidis* Lindl. ludentes; bracteae late ovato-triangulae, acutae, trinerviae, 2 mm. longae; rhachis puberula ; ovarium jam sub anthesi crassiusculum, fusiforme vel leviter obovatum, 6-costatum, sub anthesi 7–8 mm. postea 10 mm. longum. *Sepalum dorsale* oblongum, concavum, apice retusum, 3.5–4 mm. longum, 2 mm. latum; sepala lateralia pedi gynostemii 7 mm. longo affixa, triangula, obtusa ; omnia 3 tenera, clathrata, in dorso ante apicem cornu leviter recurvo instructa. *Petala* obovato-oblonga, obtusa, sepalo dorsali aequilonga et lata, non clathrata. *Labelli* bis geniculati; hypochilium cuneatum vel obtriangulum, cum carina alta triangula antice altiore membranacea per totum longitudinem; mesochilium pulvinatum, circiter subquadratum, basi utrinque lobulatum; epichilium obovato-oblongum, subbilobulum; totum labellum vi expansum 8–9 mm. longum. *Flores* roseo-albi.

Tropical Africa. Probably Uganda, *M. T. Dawe* 964.

It is much to be regretted that roots and leaves are missing. There are 6 flower-stalks fortunately all in good condition, 5 of them being about 30 cm. in height, 1 more than 40 cm. The flowers are only slightly altered by drying and remain fresh when the capsules are ripening. In size and growth the plant resembles very

much some species of *Disa* from the same country. It resembles in the structure of the lip also *P. elastica* Lindl. but this species has only a few larger flowers on very short stalks. As the roots of all the specimens are missing (and the leaves also) we may presume that the former are attached to the bark of the trees in the same way as in *P. elastica* Lindl. and that the leaves (very few and weak in *P. elastica*) are wanting, at least during the flowering season.

Polystachya ashantensis *Kraenzl.* n. sp., [*Calluniflorae*]; differt a *P. Preussii* Kraenzl. inflorescentia racemis compluribus composita, floribus minutis numerosis, labelli ungue glabro disco ecalloso.

Tota planta ad 20 cm. alta, sicca nigra. *Caules* vix pseudobulbosi, tenui-cylindracei, vaginis 2 in basi et 1 longiore tunicati. *Folia* linearia, obtusa, cum vagina ad 12 cm. longa, 5 mm. lata, coriacea. *Scapus* strictus, tenuis, a dimidio (in uno specimine a prima quarta inferiore) racemulis 1.2 cm. longis ubique florifleris e vaginis angustis acutis erumpentibus praeditus; bracteae brevissimae, triangulae, acutae, quam ovaria cum pedicellis multo breviores. *Sepalum dorsale* brevissimum, ovatum, acutum, 1 mm. longum vel vix longius; sepala lateralia antice dorsali aequalia, postice in pileum triplo longiorem, cylindraceum producta, ad 4 mm. longa. *Labelli* unguis longior quam lamina, canaliculatus, glaber, 2.5 mm. longus; lobi laterales ovati, acuti, 1 mm. longi; lobus intermedius fere cochleatus, acutus, ante apicem subtus incrassatus, in disco carunculosus haud pilosus, 1.5 mm. latus et longus, totum labellum 4 mm. longum.

Tropical Africa. Gold Coast: Ashanti, Agogo at 300 m., dry Cedar-Forest, Sept., *Chipp* 578.

The plant is of no beauty whatever but remarkable for its very long protracted lateral sepals and its spoon-shaped lip.

Polystachya spiranthoides *Kraenzl.* n. sp., [*Calluniflorae*]; differt a *P. stricta* Rolfe floribus multo minoribus, a *P. Stuhlmanni* Kraenzl. inflorescentia racemis compluribus composita.

Adest solummodo inflorescentia 17 cm. longa. *Scapus* anceps, vaginis praelongis brunneis tunicatus, sparsissime setosus; racemi 6, leviter torti, scapo arctissime appressi, erecti, 12–15-flori; bracteae triangulae, vix 1 mm. longae, acutae. *Sepalum dorsale* ovato-oblongum, acutum, concavum, vix 2 mm. longum, 1.5 mm. latum; sepala lateralia late ovata, suborbicularia, brevissime acutata, concava, 2 mm. longa, fere 2 mm. lata. *Petala* linearispathulata, apice ipso obtusata, 2 mm. longa. *Labellum* sessile; lobi laterales latissime oblongi, fere semi-orbiculares, antice rotundati; lobus intermedius subquadratus, retusus, cum apiculo acuto adeo reflexo ut lobus antice emarginatus appareat, callus brevis in ipsa basi disci; discus lobi intermedii dense farinaceo puberulus, totum labellum paulum ultra 2 mm. longum et lobis lateralibus expansis 2 mm. latum; omnia phylla flores etiam petala et labellum anguste clathrata.

Habitat unknown. Flowered at the Royal Botanic Gardens, Kew, originally from Sir Trevor Lawrence, Bart. Coll. *Pam.*

A very doubtful species which I establish with hesitation. It agrees with *P. stricta* Rolfe in all technical characters except the size, while it differs from *P. Stuhlmanni* Kraenzl. in its inflorescence and the lip. The whole appearance of the inflorescence recalls (to me at least) *Spiranthes australis* Lindl. The comparison is not a very good one but for the moment I cannot find any better. The little racemes are slightly twisted around the axis and the flowers are as small as in *Spiranthes*.

Polystachya Ugandae *Kraenzl.* n. sp., [*Superpositae*]; differt a ceteris speciebus sectionis statura multo minore, pseudobulbis vix sic dicendis caulinis, inflorescentiis brevibus paucifloris racemosis, floribus majoribus.

Epiphytica; pseudobulbi tenues, caulini, saepius leviter curvuli, omnino cataphyllis griseis vestiti, ad 4 cm. longi, vix 2 mm. crassi, paucifoliati. *Folia* linearia, 3 vel 4, apice bilobula, 4–6 cm. longa, 3 mm. lata, quam racemus brevis pauciflorus multo longiora. *Scapus* inter folia suprema fere omnino absconditus, brunneo-pilosus; flores 3–4; bracteae e basi latiore triangulae, acutae, 1.5 mm. longae; ovaria cum pedicellis ad 4 mm. longa, minute pilosa. *Sepalum dorsale* late ovatum, acutum, concavum, 3 mm. longum, basi 2.5 mm. latum; sepala lateralia oblique triangula, acuta, mentum perbreve, leviter bisaccatum formantia, ad 5.5 mm. longa, 3 mm. lata, omnia tesselata vel clathrata; mentum 3.5 mm. longum. *Petala* lineari-spathulata, apiculata, tenerrima, 2.5 mm. longa, vix 1 mm. lata, tenuissime clathrata. *Labelli* sessilis vel brevissime unguiculati, lobi laterales breves, ubi liberi divergentes, oblongi, obtusi; lobus intermedius suborbicularis vel transverse oblongus, medio subbilobulus; discus glaber vel vix farinosus; callus in basi carinaeformis, altus, membranaceus; pes gynostemii brevissimi 2.5 mm. longus. *Flores* viridi-lutei; labellum purpureo-guttatum. Fl. Novembri.

Tropical Africa. Uganda: Toro, 1500 m., *Snowden* 737 flowered at Kampala. Zanzibar: *Last*.

Differs from all the other species of this section in the slender stems and in its comparatively large flowers. The tall membranous keel on the surface of the labellum is a very good character.

XXXVI.—A REVISION OF ENGLERASTRUM.

A. H. G. Alston.

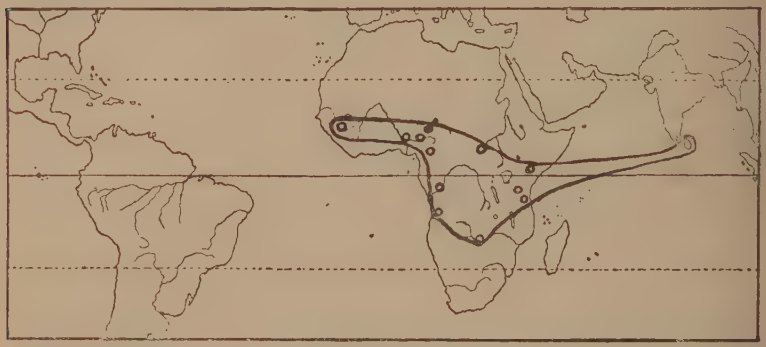
The genus *Englerastrum* was founded by Briquet* in 1894 on *E. Schweinfurthii* Briq., a plant discovered by Schweinfurth in North East Central Africa. The genus is in some respects intermediate between *Plectranthus* L'Hérit. and *Coleus* Lour. From

* Engl. Bot. Jahrb. 19:178 (1894).

the latter it is readily distinguished by the subequal calyx-teeth, and the fact that the stamens, though connate, do not form a tube. It approaches *Plectranthus* more closely, in particular the section *Isodon*, being only distinguished by its connate stamens and peculiar habit.

Five years before Briquet founded his genus, Trimen described a plant from the Ritigala Hill, Ceylon, as *Coleus elongatus*.* A recent examination of this plant suggests that it would be better placed in the genus *Englerastrum*, next to *E. scandens* Alston, *comb. nov.* (*Coleus scandens* Gürke), from which it is scarcely distinct.

Willis† suggests that *C. elongatus* Trim. was derived from the very distinct *C. Forskohlii* Briq. (*C. barbatus* Benth.). He states "its nearest relative is *C. barbatus* which also occurs on the summit of Ritigala." But it seems more reasonable to believe that the scarcely distinguishable *E. scandens* Alston from East Africa is its nearest ally, and that though now widely separated, their areas were once continuous.



Distribution of the genus ENGLERASTRUM; the small rings show the records for Tropical Africa, mainly at fairly high altitudes on the older parts of the ancient plateau. One species in Ceylon.

I wish to express my indebtedness to Mr. J. Hutchinson for his assistance.

CLAVIS SPECIERUM.

Racemi laxi; folia sessilia vel subsessilia, integra vel crenata, subpersistentia; caules rotundati vel quadrati, circiter 2 mm. diametro:

Pedicelli usque ad 3 mm. longi:

Folia ovato-suborbicularia, 1.2–2.5 cm. longa, 1–2 cm. lata, crenulata; French Guinea .....1. *djalonense.*

Folia basi et apice plus minusve acuta:

Racemi subsimplices; folia plerumque ovata; caulis rotundatus:

* Journ. Bot. 1889: 165.

† Age and Area, 151 (1922).

Florum verticillastra 1–4 mm. inter se distantia; radix ramosa; E. &. S. Trop. Africa .....2. *Schweinfurthii*.

Florum verticillastra 5–20 mm. inter se distantia, rhizoma subterraneum ; Congo .....3. *Schlechteri*.

Racemi ramosi:

Folia plerumque integra, apice obtusa leviter acuminata; Rhodesia .....4. *rhodesicum*.

Folia obovato-lanceolata, apice acuta, 1.75 cm. longa 0.6 cm. lata vel majora; Nigeria...5. *Hutchinsonianum*.

Pedicelli 15 mm. longi; folia lanceolata; caulis quadratus; Nigeria .....6. *diffusum*.

Racemi compressi, unilaterales; folia plerumque longe petiolata, crenata, caducissima (in *E. nigerico* ignota); caules quadrati, circiter 3 mm. diametro:

Flores pedicellati; caulis minute puberulus; Nigeria..... 7. *nigericum*.

Flores sessiles:

Caulis minute puberulus; flores pallide purpurei (*Trimen*); folia ovato-triangularia, subacuminata; Ceylon ..... 8. *elongatum*.

Caulis pilosus; flores coerulei (*Gürke*); folia rotundato-ovata, acuta; Tanganyika Territ. .....9. *scandens*.

1. **Englerastrum djalonense** *A. Chev.* in Journ. de Bot. 22:127 (1909).

Tropical Africa. French Guinea: on dry ferruginous plateaux between Timbo and Bouria, *Chevalier* 18495 (not seen).

2. **Englerastrum Schweinfurthii** *Briquet* in Engl. Bot. Jahrb. 19:178 (1894) ; Hiern in Cat. Welw. Afr. Pl. 860 (1900).—*Coleus dissitiflorus* Gürke in Engl. Bot. Jahrb. 19: 221 (1894).

Tropical Africa. Bongo-land: Addai, *Schweinfurth* 2532 (type). Kenya Colony: *Mitten*. Rhodesia: Sesheke, *Gairdner* 509: near Victoria Falls, *Allen* 410. Angola: Pungo Andongo; near the great cataract of the river Cuanza, near Condo, *Welwitsch* 5522.

3. **Englerastrum Schlechteri** *Alston*, comb. nov.—*Plectranthus Schlechteri* Gürke in Schlechter, Westafr. Kautschuk.-Exped. 311 (1900), nomen.

Herba ramosa; caulis rotundatus, pilosus; rhizoma subterraneum, radicibus fibrillosis. *Folia* caduca, ambitu ovata, basi cuneata, breviter petiolata, apice obtusa, 3 cm. longa, 1.75 cm. lata, distincte crenata. *Inflorescentia* racemos simplices formans; florum verticillastra 5–20 mm. inter se distantia, 1-2-flora; pedicelli 3 mm. longi; bracteae usque ad 2 mm. longae. *Calyx* 2 mm. longus, puberulus. *Corolla* non visa. *Carpella* flavo-brunnea, compressa.

Tropical Africa. Belgian Congo: Dolo, near Stanley-Pool, *Schlechter* 12490 (type). Cameroons: near river Dja, in the

primaeval forest, *Schlechter* 12769 (not seen) ; near Mnea, in the primaeval forest, 600 m., *Schlechter* 12850.

4. **Englerastrum rhodesicum** *N. E. Brown* in Kew Bull. 1922 : 31.
TROPICAL AFRICA. Rhodesia: near Mumbwa, *Macaulay* 637 (type); Livingstone, in sand, 1000 m., *Rogers* 7205.

5. **Englerastrum Hutchinsonianum** *Alston*, sp. nov.
Herba annua, ramosissima; caulis tetragonus, molliter et leviter pilosus. *Folia* caduca, lanceolata, basi cuneata, breviter petiolata, apice acuta, distante serrata vel integra. *Inflorescentia* racemos compositos formans; florum verticillastra 1–7 mm. inter se distantia, plerumque uniflora; pedicelli 2 mm. longi; bracteae usque ad 0.75 mm. longae. *Calyx* 2 mm. longus, pilosus. *Corolla* coerulea, calyce triplo longior; labium superum 0.5 mm. longum; labium inferum 1.5 mm. longum, plus minusve puberulum; tubus 1.5 mm. longus. *Stamina* basi longe connata. *Carpella* brunnea, nitentia, compressa.
TROPICAL AFRICA. Northern Nigeria: Mount Patti, Lokoja, *Dalziel* 105.

6. **Englerastrum diffusum** *Alston*, sp. nov.
Herba ramosa; caulis tetragonus, molliter pilosus. *Folia* caduca, lanceolata, vix petiolata, basi cuneata, apice obtuse cuneata, superne distante serrata. *Inflorescentia* racemos compositos formans; florum verticillastra 4–8 mm. inter se distantia, 1–2–flora; pedicelli 15 mm. longi; bracteae minutissimae. *Calyx* 1.5 mm. longus, fructu 3 mm. longus, pilosus. *Corolla* coerulea, calyce duplo longior, glabra, usque ad 3 mm. longa. *Stamina* basi leviter connata. *Carpella* brunnea, nitentia, compressa.
TROPICAL AFRICA. Nigeria: Nupe, *Barter*; Muri Province, weed in arable land, *Lamb* 72.

7. **Englerastrum nigericum** *Alston*, sp. nov.
Herba ramosa; caulis tetragonus, glaber vel minute puberulus. *Folia* caducissima. *Inflorescentia* axillaris et terminalis, racemos compositos vel simplices unilaterales formans; florum verticillastra 2 mm. inter se distantia, 1–2–flora; pedicelli 2 mm. longi ; bracteae florales minutae. *Calyx* 1.5 mm. (fructu 3 mm.) longus, pubescenti-glandulosus. *Corolla* calyce usque ad triplo longior. *Stamina* basi leviter connata. *Carpella* nitenti-brunnea, compressa.
TROPICAL AFRICA. Northern Nigeria: Katagum District, fls. blue, *Dalziel* 109.

8. **Englerastrum elongatum** *Alston*, comb. nov.—*Coleus elongatus* Trim. in Journ. Bot 1889: 165; Handb. Fl. Ceylon 3: 375, t. 74.
CEYLON. Only found near the summit of Ritigala Hill, North-central Prov., at about 750 m. trailing over rocks, fl. July, *Trimen* (type).

9. **Englerastrum scandens** *Alston*, comb. nov.—*Coleus scandens* Gürke in Engl. Bot. Jahrb. 19:221 (1894),

Tropical Africa. Tanganyika Territory: Usambara; Mswga to Kwa Mshusa, 1300 m., *Holst* 9119, 9120a (co-types); Marangu, Kilimanjaro, 1450 m., *Volkens* 1431.

XXXVII.—MISCELLANEOUS NOTES.

In the recent King's Birthday Honour List the Director received the Honour of the Companionship of The Most Distinguished Order of St. Michael and St. George. Mr. G. H. Cave, formerly a Student Gardener at the Royal Botanic Gardens, Kew, and lately Curator, Lloyd Botanic Gardens, Darjeeling, was appointed a Member of the Most Excellent Order of The British Empire.

We learn that Mr. F. J. Rae, B.A., B.Sc., B.Ag., has been appointed Government Botanist and Director of the Botanic Gardens, Melbourne, in the place of the late Mr. William Laidlaw.

The Secretary of State for the Colonies has appointed Mr. F. C. Deighton, B.A., Mycologist, Lands and Forests Department, Sierra Leone.

A Municipal Educational Garden.—The Town Council of Swansea have recently made an interesting innovation by including amongst the other attractions of their parks, a garden of Economic Plants and a collection of the Wild Plants of the British Isles. The economic collection numbers some 430 species and includes a large number of the most important commercial plants, together with others of minor value. The old kitchen garden on the Singleton Abbey estate, now Singleton Park, has been developed for the purpose, the glass houses being used for tender subjects, and the open ground for hardier plants. The British plant collection has been formed in the same park, and an idea of its scope may be gathered from the fact that it already includes 1500 species, provision being made for water, bog, rock, dry land, and other plants. An Index of the Economic Plants has been published for the guidance of those who use the garden. It gives the scientific and common name of each plant, the part used, and the object for which it is used. There is also a shelter for the use of students, who wish to study the collections. The Council are to be congratulated on their initiative in making this innovation. Too often the activities of those who are in charge of public parks are limited to the production of playing grounds and gaudy displays of summer bedding plants, and it is refreshing to find a body of Town Councillors turning their attention to the scientific and educational side of horticulture. They are fortunate to have in Mr. D. Bliss a Parks' Superintendent

capable of carrying out their wishes to such a remarkable extent. There can be little doubt but that the innovation will have far-reaching effects. It is understood that the Parks' Superintendent will distribute seeds of many of these plants as they become available

W. D.

Glyptostrobus and Taxodium.—In Vol. XXXVII, Section B. No. 13, of the Proceedings of the Royal Irish Academy, May 1926,* Professor Augustine Henry and Miss Marion McIntyre present a critical account of the Swamp Cypresses, *Glyptostrobus* of China and *Taxodium* of America, with notes on allied genera. They begin with an historical account of *Glyptostrobus pensilis* Koch (*G. heterophyllus* Endl.), which indicates that although this species now only occurs in two localities in south-eastern China, the genus was in pre-historic times widely distributed over North America, Europe and Asia and that fossil remains show that the only remaining species represents a very ancient type of vegetation. In discussing the botanical characters the authors give macroscopic and microscopic details whenever necessary, concerning branchlets, leaves, flowers, cones, seeds and wood. The characters of seedlings and of fossil species also receive attention. *Taxodium* is discussed in the same way and a comparison is made between the wood of *Glyptostrobus*, *Taxodium*, *Wellingtonia* and *Sequoia*. The authors describe three Taxodiums—*T. distichum* Rich., *T. adscendens* Brong, and *T. mucronatum* Ten. *T. adscendens* they consider to be but a form of *T. distichum* which only bears the acerose type of foliage; but the Mexican *T. mucronatum* they regard as a distinct species both by reason of certain small botanical differences and by its distinct geographical area. Owing to various differences which occur in foliage, cones and wood, between the two trees usually met with under the names of *Sequoia sempervirens* and *S. gigantea*, the authors have retained the name of *Wellingtonia gigantea* for the latter species, a name that was given to the tree by Lindley in 1853. The results of their critical examination of the wood of these four genera will be found to be very useful, more particularly as in addition to the stem wood, critical examinations have been made of the "knees" or pneumatophores of *Taxodium* and *Glyptostrobus* growing in swampy soil. Six full page plates of drawings of shoots, flowers, cones, seeds and wood, give additional value to the work. There are also two full page photographs of the Swamp Cypresses.

W. D.

Botanical Magazine.—The third part of Volume CLI (1925) was published on June 21st, 1926, and contains plates and descriptions of the following plants:—

Actinidia kolomikta Max. (t.9093), from Eastern Asia; *Spiranthes Pamii* Braid (t.9094), a native of the Western Argentine;

* Obtainable from Messrs. Williams & Norgate, London, and from Messrs. Hodges, Figgins & Co., Dublin. Price 1s. 6d.

Rhododendron saluenense Franch. (t. 9095), from North-west Yunnan; *Cordyline indivisa* Steud. (t.9096), a native of the North and South Island, New Zealand; *Jasminum Beesianum* Forrest & Diels (t.9097), a native of Central Szechuan, Kweichou and North Yunnan; *Polygonum campanulatum* Hook.f. (t.9098), from India and China; *Pyracantha atalantioides* Stapf and *P. yunnanensis* Chittenden (t.9099), from China; *Primula siamensis* Craib (t.9100), a native of the mountains of North-west Siam; *Mammillaria conopsea* Scheidweiler (t.9101), from Central Mexico; *Berberis lycioides* Stapf (t.9102), from the North-west Himalaya; *Mesembrianthemum stellatum* Mill. (t. 9103), a native of the Karoo of Uitenhage, South Africa, and *Fritillaria Olivieri* Baker (t.9104), from Western Persia.

Selection of Hevea brasiliensis.—The Malayan Agricultural Journal for February, 1926, contains an article by Mr. F. G. Spring, dealing with yields of rubber from bud-grafted trees on Kajang Estate (Sungei Reko), and giving some particulars of successful experiments in the vegetative reproduction of rubber trees. In view of recent experiments in generative selection, to which reference was made in *Kew Bulletin*, 1919, p. 317, 1920, p. 113, 1921, p. 349 and 1925, p. 44, some extracts from Mr. Spring's paper will be of interest.

No records were kept of yields of the mother trees from which buds were taken, but they were known to have given very high yields for a number of years; they were 13 years old when used for budding purposes. The seed for stocks was not selected in any way; it was planted in the field, at stake, and budded when one year old. Budding in the field commenced in October and November, 1921. The time from cutting back the seedlings to the beginning of December, 1925, was approximately 4 years.

Tapping commenced in the last week in August, 1925, on a half spiral daily cut at 20 inches from the ground; it was continued for five and a-half weeks, after which the trees were rested for a similar period. On November 8th, 1925, the half spiral left cut was re-opened, and the system of tapping was changed to alternate day tapping; when records were first taken on the 3rd December, 1925, 4 inches of bark had been removed. Mr. Spring made 14 records of yields, visiting the estate on each occasion, seeing the tapping conducted, and himself collecting and taking away the latex. The rubber was subsequently weighed at the office of the Department of Agriculture, Kuala Lumpur.

The author gives three tables showing results from selected and numbered trees: (1) With bud-grafted trees Clone I (one group of which contains 308 trees), the highest average yield was 24·5 grams per tapping, the poorest yield was 9·1 grams per tapping. (2) With bud-grafted trees mixed Clones 1 and 9 (a mixed Clone of 94 trees), the highest average yield was 28·7 grams per tapping, the poorest 12·3 grams per tapping. (3) With the control trees (non-budded), the highest average yield was 12·6 grams per tapping and

the poorest 2·3 grams per tapping. The number of control trees distributed throughout the budded area occupied by Clones 1 and 9 is 31; at the time of writing these were approximately 5 years old.

The trees from which these test yields were obtained were selected indiscriminately throughout the area, previous to the first day's experimental tapping. As far as was possible the control trees were selected adjacent to the budded trees from which the yields were taken. The budded area tested by tapping on Kajang and Sungei Reko Estates is approximately 70 acres in extent.

The characteristics of the budded trees are low branching, similarity in appearance of trees of the same Clone, large leaves and dark green foliage, and clean bark. The bark renewal of the budded trees appears to be satisfactory.

It would not be advisable to conclude this notice without giving the guarded opinion of Mr. Spring that "although it is realised from a statistical point of view that it would not be correct to arrive at any definite conclusions, the figures obtained do show remarkably higher yields in the case of the budded trees."

J. H. H.

Life of Plants*.—A considerable number of well-written books, introducing the general reader to the study of botany, have been published in the last few years. Some of these have not reached so wide a public as is desirable on account of their cost. The compact and attractively printed and illustrated work now issued by the Clarendon Press at a very moderate price should have a wide circulation. The author desired "to suggest that Science is more than a body of doctrine—an illumination of life". With a wide range of subject matter arranged in nine chapters he has most certainly succeeded in giving a compact up-to-date biography of many aspects of plant life. As would be judged from the title, the basis of the book is the physiology of plants, a subject which readily lends itself to popular exposition. It is, however, rare to find allegories and similes used so aptly and yet in so restrained a manner as here. A clearly written chapter on variation, evolution and heredity is included. It is to be regretted that no bibliographical references are given, to serve as guide posts for the serious reader directing him to further reliable literature.

Grasses and Fodder Plants of New South Wales†.—Mr. Breakwell has spent many years in experimental work, the results of which have been published from time to time in the Agricultural Gazette of New South Wales. These results, together with much additional information, have been embodied in the present work.

---

* Life of Plants, by Sir Frederick Keeble, Oxford, Clarendon Press, 1926, pp. xii. + 256, ill. 52. Price 5s.

† The Grasses and Fodder Plants of New South Wales, by E. Breakwell. Govt. Printer, Sydney, New South Wales, 1923, pp. 370 + vii., figs. 183. Price 6s.

The first part of the book deals with grasses, both native and exotic, and the second with other fodder plants. The opening thirty-six pages give much valuable information on such subjects as good and bad pasture grasses, choice of mixtures, palatability of grasses, germination, methods of sowing, management and improvement, pastures, lawn grasses, weeds, etc. A non-technical classification follows, based on easily observed characters in which the commoner economic grasses are divided into nine sections. Each section, consisting of a number of genera, is accompanied by a simple key, as are the genera with more than one species. Most of the species are illustrated, and good cultural details are given.

The second part deals with Lucerne, Clovers, Vicias, etc. Several chapters of this part are by Mr. J. N. Whittet on similar lines to those on the grasses.

The book will be found of use to many besides Australian farmers, especially in countries where similar climatic conditions prevail, such as South Africa and parts of India.

Flora of the Transvaal*.—To students of African botany an area such as that of the Transvaal is of considerable interest from many points of view. On account of its geographical situation, besides a large percentage of endemic species, outliers from the great Tropical African flora to the north here meet those from the Cape flora to the South, the result being an assemblage of plants of very diverse form and affinity. Consequently they present no little difficulty in their taxonomic treatment, and Dr. Burtt Davy is to be warmly congratulated on his public spiritedness in providing, mostly at his own expense and risk, this handy Manual of the Flowering Plants and Ferns of the area, including Swaziland. As a large number of species extend into adjacent territories, the manual should also prove useful over a much wider field than that indicated in the title, especially for the Orange Free State, Bechuanaland, parts of Natal, and even for Rhodesia.

The author's statement that "the publication of a local *Flora* stimulates the collection and study of plants" cannot be too strongly emphasized. He has himself had the advantage of studying the flora of the Transvaal in the field, and he divides the country into two main zones, A. the Tropical and Sub-tropical Plateau Zone, and B, the Warm Temperate Plateau and Montane Zone, the latter including most of the Highveld and the Drakensberg Range. In the text the phytogeographical range of each species is indicated by reference to the Magisterial Districts, of which there are twenty-three. A little practice will soon accustom the student

---

* A Manual of the Flowering Plants and Ferns of the Transvaal with Swaziland, South Africa, by Joseph Burtt Davy. Part I. Pteridophyta to Bombacaceæ; pp. 269, illustrated, 15s. net. Longmans, Green & Co., Ltd., 39, Paternoster Row, London, E.C.4 (1926).

to the abbreviations used for these districts. Considerable space has been saved by the abbreviation of words used repeatedly in the text and by the condensation of generic and specific descriptions in key form. In this way the essential characteristics of genera and species are emphasized. If fuller descriptions are necessary, reference is given under each genus to the *Flora Capensis* or other works.

In this first part of 269 closely printed pages is included also an Analytical Key to the families of Flowering Plants (Dicotyledons) Gymnosperms and Ferns, 40 line drawings by W. E. Trevithick and Mrs. Burtt Davy and numerous critical and economic notes. The latter especially should be useful to farmers and others on account of several plants being poisonous to stock. There is also a chapter on plant collecting, an illustrated glossary of terms and list of abbreviations, and in addition, a somewhat unusual feature in a local flora, latin descriptions of 131 new species and varieties of plants.

In his introductory chapter the author expresses dissatisfaction with the existing systems of classification and has adopted the sequence of families proposed by Hutchinson in the Kew Bulletin and in his recent book. This will greatly facilitate comparison with the projected regional floras of Tropical Africa now in preparation at Kew.

No doubt expense has had to be considered very closely in the publication of this work, as its circulation will be necessarily somewhat limited. Otherwise a thicker paper and somewhat larger print with wider spacing would have been a great advantage, especially for the descriptive keys, which will be most used by the field botanist.

The Classification of Flowering Plants.—The artificial key to " The Families of Flowering Plants " referred to in a notice of that book in Kew Bulletin, 1926, p. 143, has now been published separately in pamphlet form.* In this convenient form one of the most interesting and useful sections of Mr. Hutchinson's book is now available at a small price.

---

* Key to the Families of the Dicotyledons, by J. Hutchinson. Macmillan & Co., St. Martin's Street, London. 1926. Pp. 54. Price 2s.

Printed under the authority of His Majesty's Stationery Office
By Wyman & Sons, Limited, Fetter Lane, London, E.C. 4.